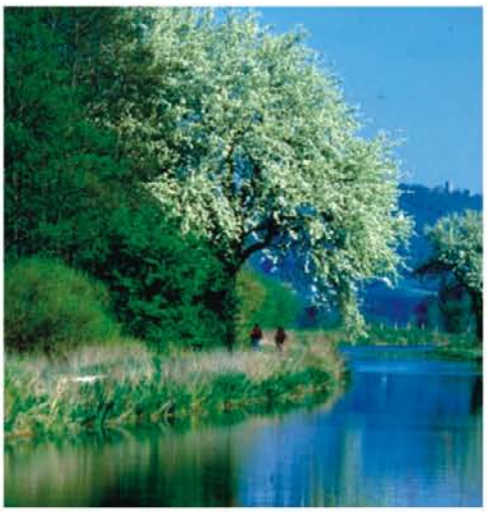

NEW AGE

BASICS OF ENVIRONMENT AND ECOLOGY

Anubha Kaushik
C.P. Kaushik

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ENVIRONMENT
AND ECOLOGY

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Preface

Exponential growth of human population coupled with ways to attain high standards of living through technological advancement has resulted in widespread contamination of the environment at the global level. During the past few decades, rapid industrialization, wanton exploitation of natural resources and excessive use of environmentally abhorrent materials have resulted in discernible environmental disruptions threatening the life support system. Such changes may jeopardize the very existence of life on this planet which evolved over millions of years. During these years millions of species of microorganisms, plants and animals co-evolved, the most intelligent of them being the human being, who eventually became the master of all other species and started exploiting them. Human-centric approach of development has already damaged the nature to a large extent. This has caught attention of scientists, academicians, social scientists, policy makers and the like necessitating discussions at various international fora. The objective of environmental protection cannot be achieved without involvement of the masses at the grass root level.

In this book basic concepts of Environment and Ecology have been introduced and analysed in a simple manner for under graduate classes in all disciplines.

Key features of the book include a simple and holistic approach with illustrations, tables and specific case studies. The basic terminologies have been defined in the text while introducing the topics and some useful terms mentioned in the text have been explained in the glossary for an easy grasp by students of all disciplines.

We are indebted to all the scientists, scholars and grass-root level workers in the field of environmental studies whose work and observations form the basis of our understanding of various scientific and social aspects of environment.

We thank M/S. New Age International (P) Ltd., Publishers, New Delhi for their wonderful work in bringing out this edition of the book in its present form.

Anubha Kaushik • **C.P. Kaushik**
(nee Sinha)

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1

Environment and Ecology

1.1 INTRODUCTION

'Environment' is a term derived from the French word 'Environner' that means 'to surround'. There was a time when environment just meant surroundings. It was used to describe the physical world surrounding us including soil, rocks, water and air. Gradually it was realized that the enormous variety of plants, animals and micro-organisms on this earth, including human beings are an integral part of the environment. Hence, to make a sensible definition of environment, it was necessary to include the interactions and inter-relationships of all living organisms with the physical surroundings.

Later, it was further recognised that all types of social, cultural and technological activities carried out by human beings also have a profound influence on various components of the environment. Thus various built structures, materials and technological innovations also became a part of the environment. So now all biological (biotic) and non-biological (abiotic) entities surrounding us are included in the term 'environment'. The impact of technological and economic development on the natural environment may lead to degradation of the social and cultural environment. Thus, environment is to be considered in a broader perspective where the surrounding components as well as their interactions are to be included.

As per Environment (Protection) Act, 1986, environment includes all the physical and biological surroundings of an organism along with their interactions. **Environment** is thus defined as **"the sum total of water, air and land and the inter-relationships that exist among them and with the human beings, other living organisms and materials."** The concept of environment can be clearly understood from Fig. 1.1.

Figure 1.1 depicts the environment of human beings. Air, water and land surrounding us constitute our environment, and influence us directly. At the same time we too have an influence on our environment due to overuse or over-exploitation of resources or due to discharge of pollutants in the air, water and land. The flora, fauna and micro-organisms as well as the man-made structures in our surroundings have a bi-directional interaction with us directly or indirectly. The totality of all these components and their interactions constitute the environment.

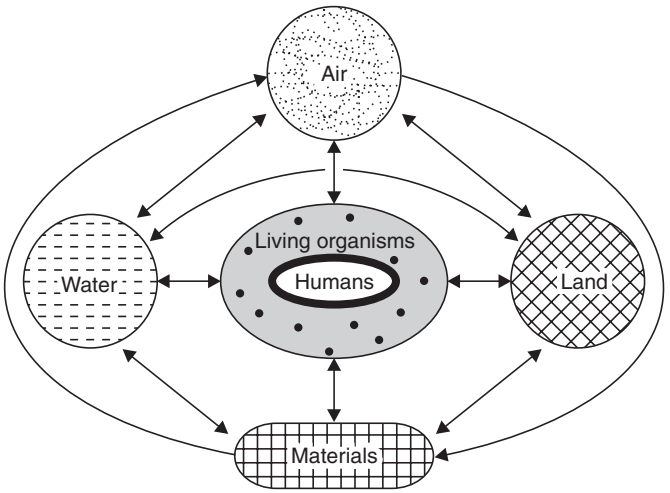


Fig. 1.1. Concept of Environment: air, water, land, living organisms and materials surrounding us and their interactions together constitute environment.

Urban environment is somewhat different from rural environment. In urban environment we can see profound influence of human beings. Most of the natural landscapes in cities have been changed and modified by man-made artificial structures like multi-storeyed buildings, commercial complexes, factories, transportation networks and so on. Urban air, water and soil are loaded with various types of chemicals and wastes. Diversity of plants and animals is much less as compared to rural environment. Urban population is more dense and has greater energy demands.

1.2 SCOPE

Environmental studies as a subject has a wide scope. It encompasses a large number of areas and aspects, which may be summarized as follows:

- Natural resources—their conservation and management
- Ecology and biodiversity
- Environmental pollution and control
- Social issues in relation to development and environment
- Human population and environment

These are the basic aspects of environmental studies which have a direct relevance to every section of the society. Environmental studies can also be highly specialized concentrating on more technical aspects like environmental science, environmental engineering or environmental management.

In the recent years, the scope of environmental studies has expanded dramatically the world over. Several career options have emerged in this field that are broadly categorized as:

(*i*) **Research & Development (R & D) in environment:** Skilled environmental scientists have an important role to play in examining various environmental problems in a scientific manner and carry out R & D activities for developing cleaner technologies and promoting sustainable development.

There is a need for trained manpower at every level to deal with environmental issues. Environmental management and environmental engineering are emerging as new career opportunities for environmental protection and management. With the pollution control laws becoming more stringent, industries are finding it difficult to dispose off the wastes produced. In order to avoid expensive litigation, companies are now trying to adopt green technologies, which would reduce pollution.

Investing in pollution control technologies will reduce pollution as well as cut on costs for effluent treatment. Market for pollution control technology is increasing the world over. Cleaning up of the wastes produced is another potential market. It is estimated to be more than $ 100 billion per year for all American business. Germany and Japan having more stringent laws for many years have gained more experience in reducing effluents. Still there is a $ 200 billion market for cleaning up the former East Germany alone. In India also the Pollution Control Boards are seriously implementing pollution control laws and insisting on upgradation of effluents to meet the prescribed standards before they are discharged on land or into a water body. Many companies not complying with the orders have been closed or ordered to shift.

(*ii*) **Green advocacy:** With increasing emphasis on implementing various Acts and Laws related to environment, need for environmental lawyers has emerged, who should be able to plead the cases related to water and air pollution, forest, wildlife etc.

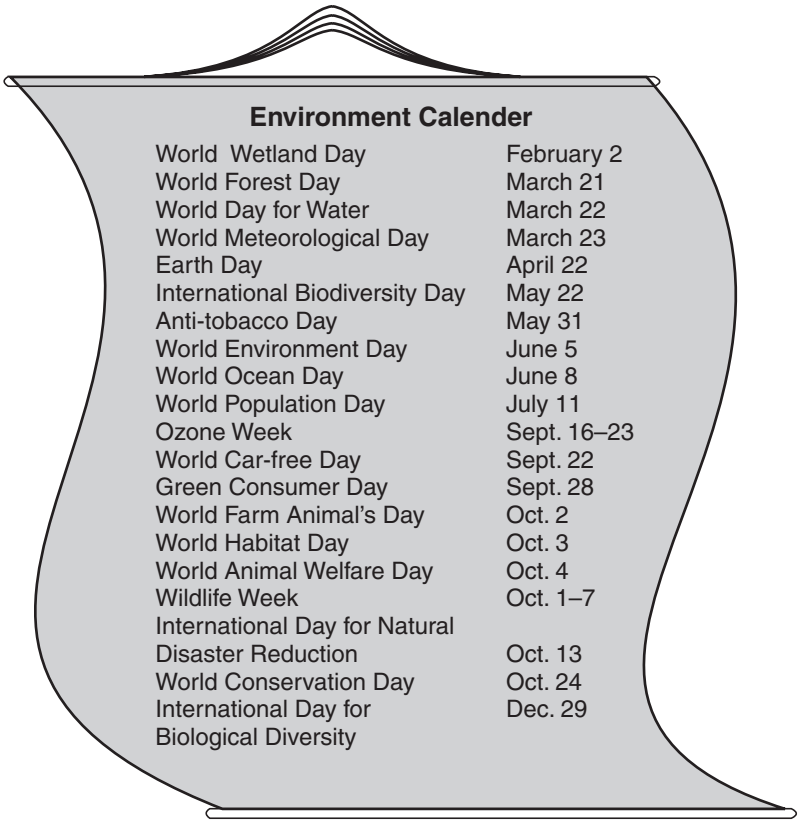
(*iii*) **Green marketing:** While ensuring the quality of products with ISO mark, now there is an increasing emphasis on marketing goods that are environment friendly. Such products have ecomark or ISO 14000 certification. Environmental auditors and environmental managers would be in great demand in the coming years.

(*iv*) **Green media:** Environmental awareness can be spread amongst masses through mass media like television, radio, newspaper, magazines, hoardings, advertisements etc. for which environmentally educated persons are required.

(*v*) **Environment consultancy:** Many non-government organisations (NGOs), industries and government bodies are engaging environmental consultants for systematically studying and tackling environment related problems.

1.3 IMPORTANCE OF ENVIRONMENT

Environment belongs to all and is important to all. Whatever be the occupation or age of a person, he will be affected by environment and also he will affect the environment by his deeds. That is why we find an internationally observed environment calender to mark some important aspect or issue of environment.


Environment Calender
World Wetland Day February 2
World Forest Day March 21
World Day for Water March 22
World Meteorological Day March 23
Earth Day April 22
International Biodiversity Day May 22
Anti-tobacco Day May 31
World Environment Day June 5
World Ocean Day June 8
World Population Day July 11
Ozone Week Sept. 16–23
World Car-free Day Sept. 22
Green Consumer Day Sept. 28
World Farm Animal's Day Oct. 2
World Habitat Day Oct. 3
World Animal Welfare Day Oct. 4
Wildlife Week Oct. 1–7
International Day for Natural Disaster Reduction Oct. 13
World Conservation Day Oct. 24
International Day for Biological Diversity Dec. 29

(*a*) **Global vs. Local Importance of Environment**

Environment is one subject that is actually global as well as local in nature.

Issues like global warming, depletion of ozone layer, dwindling forests and energy resources, loss of global biodiversity etc. which are going to affect the mankind as a whole are global in nature and for that we have to think and plan globally.

However, there are some environmental problems which are of localized importance. For dealing with local environmental issues, e.g. impact of mining or hydroelectric project in an area, problems of disposal and management of solid waste, river or lake pollution, soil erosion, water logging and salinization of soil, fluorosis problem in local population, arsenic pollution of groundwater etc., we have to think and act locally.

In order to make people aware about those aspects of environment with which they are so intimately associated, it is very important to make every one environmentally educated.

(*b*) **Individualistic Importance of Environment**

Environmental studies is very important since it deals with the most mundane problems of life where each individual matters, like dealing with safe and clean drinking water, hygienic living conditions, clean and fresh air, fertile land, healthy food and sustainable development. If we want to live in a clean, healthy, aesthetically beautiful, safe and secure environment for a long time and wish to hand over a clean and safe earth to our children, grandchildren and great grandchildren, it is most essential to understand the basics of environment.

1.4 NEED FOR PUBLIC AWARENESS

(*a*) **International Efforts for Environment**

Environmental issues received international attention about 35 years back in Stockholm Conference, held on 5th June, 1972. Since then we celebrate **World Environment Day** on **5th June.** At the United Nations Conference on **Environment and Development** held at Rio de Janeiro, in 1992, known popularly as **Earth Summit,** and ten years later, the **World Summit on Sustainable Development,** held at Johannesberg in 2002, key issues of global environmental concern were highlighted. Attention of general public was drawn towards the deteriorating environmental conditions all over the world.

Award of the Nobel Peace Prize (2004) to an environmentalist, for the first time, came as a landmark decision, showing increasing global concern towards environmental issues and recognition to efforts being made for environmental conservation and protection.

NOBEL PEACE PRIZE, 2004 AND 2007 FOR ENVIRONMENTALISTS

The 2004 Nobel Peace Prize was awarded to Kenyan Environmentalist **Wangari Maathai** for her contribution to sustainable development, democracy and peace. This is the greatest recognition given to the cause of environment at international level. The Norwegian Nobel Committee, while awarding the prize, expressed the views ***"Peace on Earth depends on our ability to secure our living Environment".***

Wangari Maathai

Maathai, Kenya's Deputy Environment Minister is the founder of Kenya based **Green Belt Movement.** This movement comprising mainly of women has planted about 30 million trees across Africa. This has helped in slowing desertification, preserving forest habitats for wildlife and food for future generations and has helped combat poverty.

Maathai has given a beautiful slogan ***"When we plant new trees, we plant the seeds of peace."***

Nobel peace prize, 2007 was awarded jointly to Intergovernmental Panel on Climate Change (IPCC) headed by Indian Environmentalist Dr. R.K. Pachauri, and former US vice-president Al Gore. IPCC, the UN body comprising of 3,000 experts from various fields is an authority on global warming and its impacts. The award to IPCC is in appreciation of its efforts to build up and disseminate greater knowledge about man-made climate change and to lay the foundation for the measures that are needed to counteract such change. Al Gore is "probably the single individual who has done most to create greater world-wide understanding to the measures that need to be adopted," observed the Norwegian Nobel Committee while naming the joint winner of the award.

Former US vice-president Al Gore R.K. Pachauri

(*b*) **Public Awareness for Environment**

The goals of sustainable development cannot be achieved by any government at its own level until the public has a participatory role in it. Public participation is possible only when the public is aware about the ecological and environmental issues.

The public has to be educated about the fact that if we are degrading our environment we are actually harming our own selves. This is because we are a part of the complex network of environment where every component is linked up. It is all the more important to educate the people that sometimes the adverse impact of environment are not experienced until a threshold is reached. So we may be caught unawares by a disaster.

A drive by the government to ban the littering of polythene cannot be successful until the public understands the environmental implications of the same. The public has to be made aware that by littering polythene, we are not only damaging the environment, but posing serious threat to our health.

There is a Chinese proverb ***"If you plan for one year, plant rice, if you plan for 10 years, plant trees and if you plan for 100 years, educate people."*** If we want to protect and manage our planet earth on sustainable basis, we have no other option but to make all persons environmentally educated.

(*c*) **Role of Contemporary Indian Environmentalists in Environmental Awareness**

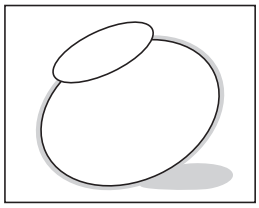
In our country, efforts to raise environmental awareness have been initiated, and several landmark judgements related to environmental litigations have highlighted the importance of this subject to general public. Two noted personalities who need a mention here, are Justice Kuldeep Singh, known popularly as ***the green judge*** and Sh. M.C. Mehta, ***the green advocate,*** who have immensely contributed to the cause of environment.

In 1991, the Supreme Court of our country issued directives to make all curricula environment-oriented. This directive was, in fact, in response to a Public Interest Litigation (PIL) filed by *M.C. Mehta vs. Union of India (1988)* that prompted the apex court to give a mandate for creating environmental awareness among all citizens of India. Based on the judgement, Environmental Studies is being taught as a compulsory course to all students.

There are some environmentalists in the present time who have made a mark in our country through environmental activism. Sh. Sunderlal Bahuguna, known for his 'Chipko movement' and 'Tehri Bachao Andolan', Smt. Medha Patkar and Ms. Arundhati Roy known for their 'Narmada Bachao Andolan', the Magsaysay awardee Sh. Rajender Singh known for his water conservation efforts are some such contemporary figures. Salim Ali is a renowned ornithologist, famous for his work on Indian birds. In modern India, our late Prime Minister Mrs. Indira Gandhi was instrumental in introducing the concept of environmental protection in the Constitution of India as a fundamental duty while Mrs. Maneka Gandhi, formerly environment minister, has worked a lot for the cause of wildlife protection. Citizens report on environment was first published by late Sh. Anil Aggarwal, the founder Chairman of Centre for Science & Environment. Even with many such key persons leading the cause to environment, India is yet to achieve a lot in this field.

(*d*) **Role of Government**

Concept of Ecomark: In order to increase consumer awareness about environment, the Government of India has introduced a scheme of eco-labelling of consumer products as 'Ecomark' in 1991. It is an 'earthen pitcher'–a symbol of eco-friendliness and our traditional heritage. A product that is made, used or disposed off in a harmless manner is called eco-friendly and is awarded this eco-mark.



Ecomark of India

In a drive to disseminate environmental awareness **'Eco-Clubs'** for children and **'Eco-task force'** for army men have also been launched by the government.

Today everybody talks of environment, but only a few have clear ideas about what needs to be done and still fewer people have the actual experience or expertise in the field. Unfortunately, environmental awareness campaigns have very often been exploited for political propaganda rather than being an integral part of our educational programmes in theory and practice. "*Environment" is very wrongly taken as a "fashion" by all walks of life, hardly realizing that it is our "real-life-situation" and our sustenance and security are at stake*.

To sum up, it may be said that it is absolutely essential to create environmental awareness because:

(*i*) Environment belongs to all and participation of masses is a must for successful implementation of environmental protection plans.

(*ii*) Living in a technologically developing society, our lifestyles and attitudes have become self-oriented. Environmental awareness is needed to change the mindset of modern society for an earth-oriented approach.

(*iii*) There is a need to make the public environmentally aware of the serious health impacts of environmental pollution and their right to live in a clean and healthy environment.

(*iv*) There is an urgent need to create awareness amongst people that we have no other option but to follow sustainability principles. Only then life of mankind on this earth would be secure and our future generations would be safe.

Henry D. Thoreau had rightly said ***"What's the use of a beautiful house if you don't have a decent planet to put it on?"*** Even if we begin today, the restoration is expected in the next 40–50 years.

1.5 CONCEPT OF ECOLOGY AND ECOSYSTEM

Various kinds of life supporting systems like the forests, grasslands, oceans, lakes, rivers, mountains, deserts and estuaries show wide variations in their structural composition and functions. However, they all are alike in the fact that they consist of living entities interacting with their surroundings exchanging matter and energy. How do these different units like a hot desert, a dense evergreen forest, the Antarctic Sea or a shallow pond differ in the type of their flora and fauna, how do they derive their energy and nutrients to live together, how do they influence each other and regulate their stability are the questions that are answered by Ecology.

The term Ecology was coined by Earnst Haeckel in 1869. It is derived from the Greek words *Oikos*- home + *logos*- study. So **ecology deals with the study of organisms in their natural home**

interacting with their surroundings. The surroundings or environment consists of other living organisms (biotic) and physical (abiotic) components. Modern ecologists believe that an adequate definition of ecology must specify some unit of study and one such basic unit described by Tansley (1935) was ecosystem. **An ecosystem is a self-regulating group of biotic communities of species interacting with one another and with their non-living environment exchanging energy and matter.** Now **ecology** is often defined as **"the study of ecosystems".**

An ecosystem is an integrated unit consisting of interacting plants, animals and micro-organisms whose survival depends upon the maintenance and regulation of their biotic and abiotic structures and functions. The ecosystem is thus, a unit or a system which is composed of a number of sub-units, that are all directly or indirectly linked with each other. They may be freely exchanging energy and matter from outside—an *open ecosystem* or may be isolated from outside in term of exchange of matter—a *closed ecosystem.*

Ecosystems show large variations in their size, structure, composition etc. However, all the ecosystems are characterized by certain basic structural and functional features which are common. Composition and organization of biological communities and abiotic components constitute the structure of an ecosystem. Thus, ecosystems have basically two types of components, the biotic and abiotic, as described below:

(*a*) **BIOTIC COMPONENTS:** Different living organisms constitute the biotic component of an ecosystem and belong to the following categories:

(*i*) **Producers:** These are mainly producing food themselves *e.g.,* Green plants produce food by photosynthesis in the presence of sunlight from raw materials like water and carbon dioxide. They are known as *photo-autotrophs* (auto = self, photo = light, troph = food).

There are some *chemo-autotrophs*, which are a group of bacteria, producing their food from oxidation of certain chemicals. *e.g.* sulphur bacteria.

(*ii*) **Consumers:** These organisms get their food by feeding on other organisms. They are of the following types:

- Herbivores—which feed on plants *e.g.* rabbit, insect.
- Carnivores—which feed on herbivores as secondary carnivores (*e.g.,* frog, small fish) or tertiary carnivores (*e.g.,* snake, big fish), which feed on other consumers.
- Omnivores—which feed on both plants and animals *e.g.,* humans, rats, many birds.
- Detritivores—which feed on dead organisms *e.g.,* earth worm, crab, ants.

(*iii*) **Decomposers:** These are micro-organisms which break down organic matter into inorganic compounds and in this process they derive their nutrition. They play a very important role in converting the essential nutrients from unavailable organic form to free inorganic form that is available for use by plants *e.g.,* bacteria, fungi.

(*b*) **ABIOTIC COMPONENTS:** Various physico-chemical components of the ecosystem constitute the abiotic structure:

(*i*) Physical components include sunlight, solar intensity, rainfall, temperature, wind speed and direction, water availability, soil texture etc.

(*ii*) Chemical components include major essential nutrients like C, N, P, K, H_2, O_2, S etc. and micronutrients like Fe, Mo, Zn, Cu etc., salts and toxic substances like pesticides.

These physico-chemical factors of water, air and soil play an important role in ecosystem functioning.

Every ecosystem performs the following important functions:

(*i*) **It has different food chains and food webs.** Food chain is the sequence of eating and being eaten. *e.g.,*

Grass → Grasshopper → Frog → Snake → Hawk

Phytoplanktons (water-algae) → water fleas → small fish → large fish (Tuna)

These are known as **grazing food chain**—which start with green plants and culminate with carnivores.

Another type is **detritus food chain**—which starts with dead organic matter. *e.g.,*

Leaf litter in a forest → Fungi → bacteria

Food chains are generally found to be interlinked and inter-woven as a network and known as **Food Web.** There are several options of eating and being eaten in a food web. Hence these are more stable.

(*ii*) **There is uni-directional flow of energy in an ecosystem.** It flows from sun and then after being captured by primary producers (green plants), flows through the food chain or food web, following the laws of thermodynamics. At every successive step in the food-chain, there is huge loss of about 90% of the energy in different processes (respiration, excretion, locomotion etc.) and only 10% moves to next level (Ten per cent law of energy flow).

(*iii*) **Nutrients (Materials) in an ecosystem move in a cyclic manner.** The cycling of nutrients takes place between the biotic and abiotic components, hence known as biogeochemical cycles (bio = living, geo = earth, chemical = nutrients).

(*iv*) **Every ecosystem functions to produce and sustain some primary production (plant biomass) and secondary production (animal biomass).**

(*v*) **Every ecosystem regulates and maintains itself and resists any stresses or disturbances up to a certain limit.** This self regulation or control system is known as **cybernetic system**.

1.6 BALANCED ECOSYSTEM

Ecosystems have a unique property of self-regulation. The ecosystem comprising various sub-components of biotic and abiotic nature, which are inter-linked and inter-dependent, have an inherent property to resist change. That means, the ecosystems have a property to tolerate external disturbance or stress. This property is known as **homeostasis.** The ecosystems have a definite structure comprised of certain types of living organisms, which have a definite place and role in the ecosystem, as defined by their position in the food-web. Together, in interaction with the abiotic components, these ecosystems perform

the functions of energy flow and material cycling, and finally give a desired output in the form of productivity. Every ecosystem can operate within a range of conditions, depending upon its **homeostasis** (capacity to resist change). Within its homeostatic plateau, the ecosystem has the potential to trigger certain feedback mechanisms which help in maintaining the ecosystem functioning by countering the disturbances. Such **deviation-counteracting feedbacks** are known as **negative feedback mechanisms.** Such feedback loops help in maintaining the ecological balance of the ecosystem.

A balanced ecosystem has basic biotic components which have evolved with time to suit the environmental conditions. The flow of energy and cycling of nutrients take place in a definite pattern in such an ecosystem, under a set of physical environment.

However, as the outside disturbance or stress increases beyond a certain limit (exceeding the homeostatic plateau of the ecosystem), the balance of the ecosystem is disrupted. This is because now another type of feedback mechanisms, which are **deviation accelerating mechanisms** start operating. Such feedbacks are called **positive feedback** mechanisms, which further increase the disturbances caused by the external stress and thus take the ecosystem away from its optimal conditions, finally leading to collapse of the system.

Figure 1.2 depicts the control system of a balanced ecosystem within a range.

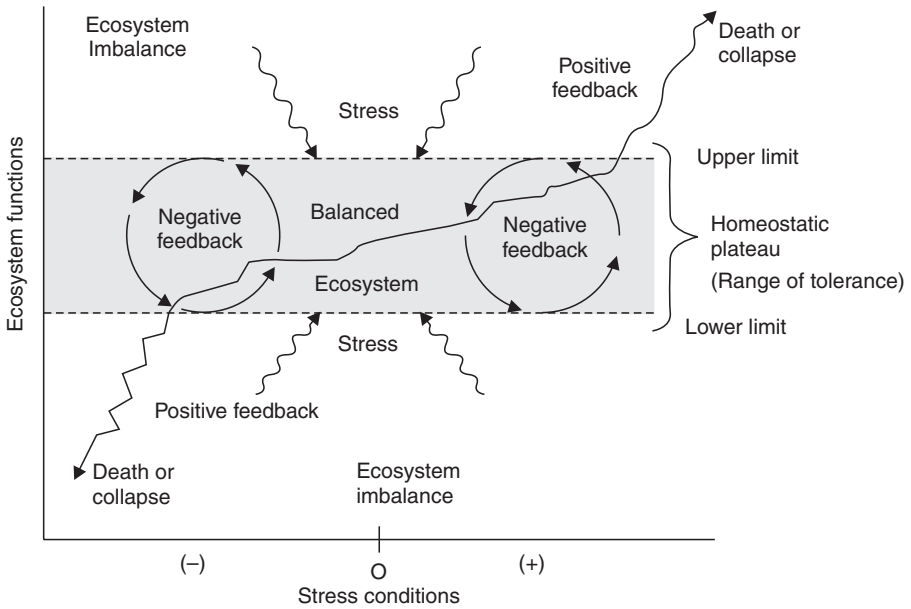


Fig. 1.2. Ecosystem regulation by homeostasis. On application of a stress, the negative feedback mechanisms start operating, trying to counter the stress and regulate the balance of the system but beyond the homeostatic plateau, positive feedback starts which further accelerate the stress effects causing ecosystem imbalance.

To understand the concept we can consider the following example.

Carbon dioxide is required by green plants to manufacture their food during photosynthesis and the food produced by green plants is actually the base of food chains, energy flow and material cycles. The ecosystems have an excellent balance of regulating the levels of carbon dioxide through carbon

cycle, where all living organisms produce CO_2 during respiration and the green plants use them up during photosynthesis, liberating oxygen. Upto certain limits, increase in CO_2 concentrations can help in improving production by green plants. But beyond a limit, the increased CO_2 will cause an imbalance in the ecosystem triggering various harmful positive feedbacks. As a result, several adverse environmental impacts occur including global warming, changing rainfall patterns, crop insecurity, storms, flooding, emergence of new types of pests—all leading to degradation of the ecosystem.

I. QUESTIONS

1. What is the need for studying environmental issues?
2. What is the scope of environmental education?
3. How would environmental awareness help to protect our environment?
4. Define environment.
5. How does urban environment differ from rural environment?
6. What is meant by 'Ecomark'?
7. How do we apply Mathematics and Engineering aspects to environmental studies?
8. What is green marketing?
9. Define ecology and ecosystems.
10. What are the biotic and abiotic components of an ecosystem?
11. What are food chains and food webs? Give examples and discuss their significance.
12. What are the types of feedback mechanisms regulating an ecosystem?
13. What are the functions of an ecosystem?

II. OBJECTIVE TYPE QUESTIONS

(A) FILL IN THE BLANKS

1. The term 'Environment' has been derived from the French word ..... which means to encircle or surround.
2. The United Nations Conference on Environment and Development (Earth Summit) was held at ..... in ..... .
3. The World Summit on Sustainable Development was held at ..... in ..... .
4. Sunderlal Bahuguna is associated with popular environmental movements, ... and ..... .
5. Mr. ..... filed PIL (Public Interest Litigation) for creating environmental awareness among all citizens of India.
6. ..... was awarded the Nobel Peace Prize in 2004 for her contribution towards environmental conservation.
7. ..... is popularly known as green judge in India.
8. World Environment Day is celebrated on ..... .

9. Environment friendly products are given ISO certification called ISO ..... .
10. Ecomark of our country is ..... .
11. The term 'ecology' was coined by ..... and 'ecosystem' was given by..... .
12. The sequence of eating and being eaten in an ecosystem is called a ..... .
13. Microbes (bacteria) capable of producing organic food by oxidation of certain chemicals are known as ..... .
14. Movement of nutrients in an ecosystem is cyclic and flow of energy is ..... .

(B) CHOOSE THE CORRECT ANSWER

1. Environment involves the interaction between
(*a*) Air, water and living organisms
(*b*) Air, water, land and living organisms
(*c*) Air, water, land, materials and living organisms
(*d*) None of these.

2. Which of the following involves children in environmental awareness?
(*a*) Ecomark (*b*) Ecoclub
(*c*) Eco task force (*d*) All of these.

3. Which of the following is NOT a correct pair?
(*a*) World Forest Day—March 21
(*b*) Earth Day—June 5
(*c*) World Population Day—July 11
(*d*) World Day for Water—March 22.

4. Which of the following is an incorrect pair?
(*a*) R.K. Pachauri—Nobel Peace Prize
(*b*) M.C. Mehta—Green Advocate
(*c*) Rajender Singh—Water Man of India
(*d*) Medha Patekar—Chipko Movement.

5. The organisms feeding on dead organisms are called
(*a*) Carnivores
(*b*) Decomposers
(*c*) Detritivores
(*d*) Omnivores.

6. Which of the following is not an abiotic factor?
(*a*) Solar radiations (*b*) Bacteria
(*c*) Soil texture (*d*) Carbon.

(C) WRITE TRUE OR FALSE

1. Only the physical world surrounding us is our environment. (True/False)
2. Ozone week is observed during September 16–23. (True/False)
3. Ecology may be defined as ''the study of ecosystems.'' (True/False)

4. Ecosystems that freely exchange energy and matter from outside are known as closed ecosystems. (True/False)

5. An ecosystem is a group of biotic communities interacting with one another but without exchanging energy and matter with the non-living environment. (True/False)

6. Detritivores are also known as saprotrophs. (True/False)

Biotic and abiotic components of an ecosystem influence each other and are linked through energy flow and matter cycling. (True/False)

7. Food webs provide less stability to an ecosystem as compared to linear food chain. (True/False)

8. If we want to maintain the ecological balance, we should try to contribute to positive feedback mechanisms. (True/False)

9. Positive feedback mechanisms tend to take the system away from its optimal conditions. (True/False)

10. The range of tolerance of an ecosystem to a particular stress is best described by its homeostatic plateau. (True/False)

2

Human Impacts on Environment

2.1 INTRODUCTION

Human beings evolved about 40,000 years ago on the 4.6 billion year old earth. In the initial one thousand years, when human population was small and man was basically a hunter gatherer with limited requirements, his interference with natural cylces and harmony was negligible. However, with development of agricultural activities followed by industrial revolution, there were tremendous changes in the population size of human beings along with rise is quality and standards of living. Due to technological development and rapid economic growth our civilisation has reached its zenith, but at the same time it has let to serious environmental degradation. Development has changed the attitude of human beings towards nature, which has further aggravated the problems.

Let us see how our life style, consumerism, agriculture, food, shelter, economic development and industrialisation have affected our environment including air, water, land, materials, biological diversity and also the human beings and their social security.

While early human societies used to consume much less resources, with the dawn of industrial era, consumerism has shown an exponential rise. It has been related both to the increase in the population size as well as increase in our demands due to change in lifestyle. Earlier we used to live a much simpler life and used to have fewer wants. In the modern society our needs have multiplied and so consumerism of resources has also multiplied.

Our population was less than 1 million for thousands of years ever since we evolved on this earth. Today we have crossed the six billion mark and are likely to reach 11 billion by 2045, as per World Bank estimates.

2.2 MAJOR ASPECTS OF HUMAN ACTIVITIES

Consumerism has increased enormously with growing human population and growing needs in the modern era of development, which has raised our standard of living. Some important aspects associated with human activities are discussed here.

2.2.1 Food

There are thousands of edible plants and animals over the world, of which only about three dozen types constitute the major food of human beings. With increasing population, the demand for crops has increased at a rate that has laid a lot of stress on our land resources. As a result, forests have been cleared to create agricultural lands.

The Food and Agriculture Organization (FAO) of the United Nations estimated that on an average minimum caloric intake on a global scale is 2500 calories/day. People receiving 2000–2200 calories/day are said to be **undernourished,** who suffer from various deficiencies and health problems. People having deficiency of proteins are said to suffering from **malnutrition**.

About 15–20 million deaths occur annually due to malnutrition.

During the last 50 years world grain production has increased almost three times, thereby increasing per capita production by about 50%. But, at the same time population growth increased at such a rate in LDCs (Less developed countries) that it outstripped food production. Every year 40 million people (fifty per cent of which are young children between 1 to 5 years) die of undernourishment and malnutrition. This means that ***every year our food problem is killing as many people as were killed by the atomic bomb dropped on Hiroshima during World War II.*** These startling statistical figures more than emphasize the need to increase our food production, equitably distribute it and also to control population growth.

2.2.2 Shelter

With increasing population, there is also increasing pressure on finite land resources for housing. Shelter for humans or habitat development on this earth has largely taken place within about 5% of land area, which supports more than half of global population.

Both overcrowded unplanned urban settlements and unhygienic, underdeveloped rural settlements pose big challenges for the present and future generations.

Fast depletion of natural resources, shrinking land, rising pollution levels and associated health problems have forced us to re-look at the structure and design of buildings by introducing environmental approach to buildings. There is an urgent need to apply the principles of sustainability to **'built environment'.** An integrated approach is thus required with inputs from various fields including architecture, engineering, science, technology, ecology and economics. Built environment should not just be viewed as structures created for providing shelter for humans, rather these are to be viewed as dynamic interplay of spaces with judicious use for multiple purposes, which provide physical comfort and psychological satisfaction to the inhabitants, along with balanced ecological elements.

2.2.3 Economic Growth

Economic growth is required for raising the quality of life of human beings. Technological advancement leading to rapid industrialization and urbanisation have raised the standard of living in modern era, but have also led to depletion of natural resources, energy crisis and pollution of the air, water and soil. Economic growth over the world has been such that it has led to wide disparity between the developed and developing nations. The U.S.A. with just 4.7% of global population consumes 25% of the total

energy and produces 25% of total pollutants/wastes and 22% of total chlorofluorocarbons (CFC's), responsible mainly for ozone depletion.

The developing nations, still struggling with their population of teeming billions and poverty are not even able to provide basic amenities like food, safe drinking water, hygienic shelter and a livable life to millions of its people.

2.2.4 Social Security

The ultimate goal of development is to improve the quality of life, so that all humans throughout the world enjoy long, healthy, purposeful and fulfilling lives. But unfortunately the developed nations, with just 20% of global population control about 80% of global economy. At present, about 1.4 billion people (*i.e.,* about 1/4th global population) live on less than $ 1 per day. About 12% of the global population living in poor countries is suffering from undernutrition or malnutrition. Such poor people suffer from acute social insecurity because life for them is an endless struggle for survival, centred around fulfilment of basic amenities of life like drinking water, fire-wood and food. While economic development is on its zenith in developed nations, it is an irony that even now 35,000 babies die every day due to unavailability of adequate food, safe drinking water and medical facilities. It is very important to improve the quality of life in poor nations and ensure adequate food, nutrition, hygienic dwelling and education, particularly for the disadvantaged women.

Intra-generational equity has emerged as a new concept in sustainable development to ensure equitable share of resources for economic growth of the poor and their social security.

2.3 EFFECTS OF HUMAN ACTIVITIES ON ENVIRONMENT

For about 75 per cent duration of their existence on this earth, human beings have acted as hunter-gatherers. It was about 10,000 to 12,000 years ago, when a cultural shift known as 'Agricultural revolution' took place in several regions of the world, which changed the life style of humans from wandering nomadic life to a settled life. People started domesticating animals and cultivating the plant species that were useful. Gradually, population increased and so did the demands for more food production. There was a need to increase the cropped land area and increase crop yield by using technological advancements. In order to feed the livestock there was increasing demand for more grazing land. Intensive agricultural practices and overgrazing led to several offshoots that influenced our environment. In the present section we would discuss about these impacts.

Rapid development activities have been associated with more and more exploitation of various natural resources. Technological development has resulted in fast depletion of non-renewable energy resources, mainly coal and petroleum, and also various minerals. Mining activities, dam, building, urbanisation and industrialisation have all interfered with the ecological balance of nature due to large scale impacts.

2.3.1 Impacts of Agriculture

In primitive times human beings used the practice of **slash and burn cultivation or shifting cultivation.** This practice in which a forest land was cleared by burning, used for cultivation of a crop for a few

years, and as the productivity declined the land was abandoned and a fresh piece of forest land was cleared for cropping is still prevalent in many tribal areas, as in the North East Hills of India. The type of agriculture practised these days is very different from the traditional ones and their outputs in terms of yield as well as their impacts on the environment show lots of differences, as shown in Fig. 2.1.

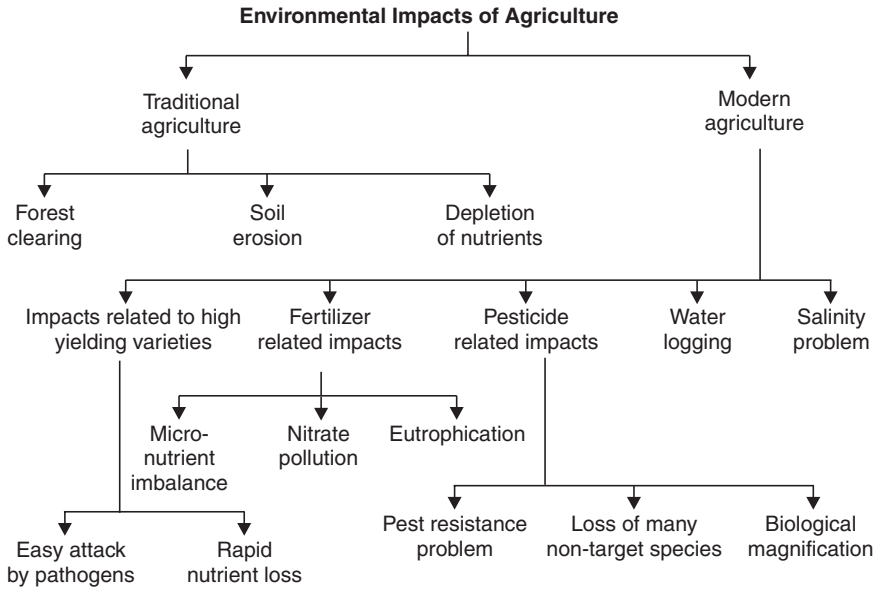


Fig. 2.1. Chain of side effects on environment due to intensive practices for increased food production

A. Traditional Agriculture and its Impacts: It usually involves a small plot, simple tools, naturally available water, organic fertilizer and a mix of crops. It is more near to natural conditions and usually it results in low production. It is still practised by about half the global population.

The main impacts of this type of agriculture are as follows:

(*i*) **Deforestation:** The slash and burn of trees in forests to clear the land for cultivation and frequent shifting result in loss of forest cover.

(*ii*) **Soil erosion:** Clearing of forest cover exposes the soil to wind, rain and storms, thereby resulting in loss of top fertile layer of soil.

(*iii*) **Depletion of nutrients:** During slash and burn the organic matter in the soil gets destroyed and most of the nutrients are taken up by the crops within a short period, thus making the soil nutrient poor which forces the cultivators shift to another area.

B. Modern Agriculture and its Impacts: It makes use of hybrid seeds of selected and single crop variety, high-tech equipments and lots of energy subsidies in the form of fertilizers, pesticides and irrigation water. The food production has increased tremendously, evidenced by "green revolution". However, it has also given rise to several problematic off-shoots as discussed below:

1. **Impacts Related to High Yielding Varieties (HYVs):** The uses of HYVs encourage monoculture *i.e.,* the same genotype (variety) is grown over vast areas. In case of an attack by some pathogen, there is total devastation of the crop by the disease due to exactly uniform conditions, which help in rapid spread of the disease.

2. **Fertilizer related problems:**

   (*a*) **Micronutrient imbalance:** Most of the chemical fertilizers used in modern agriculture have nitrogen, phosphorus and potassium (N, P, K) which are essential macronutrients. Farmers usually use these fertilizers indiscriminately to boost up crop growth. Excessive use of fertilizers cause *micronutrient imbalance*. For example, excessive fertilizer use in Punjab and Haryana has caused deficiency of the micronutrient zinc in the soils, which is affecting productivity of the soil.

   (*b*) **Nitrate pollution:** Nitrogenous fertilizers applied in the fields often leach deep into the soil and ultimately contaminate the ground water. The nitrates get concentrated in the water and when their concentration exceeds 25 mg/L, they become the cause of a serious health hazard called **"Blue Baby Syndrome"** or methaemoglobinemia. This disease affects the infants to the maximum extent causing even death. In Denmark, England, France, Germany and Netherlands this problem has been faced frequently. In India also, problem of nitrate pollution exists in many areas.

   (*c*) **Eutrophication:** Excessive use of N and P fertilizers in the agricultural fields leads to another problem, which is not related to the soil, but relates to water bodies like lakes. A large proportion of nitrogen and phosphorus used in crop fields is washed off and along with runoff water reach the water bodies causing over nourishment of the lakes, a process known as **Eutrophication** (eu = more, trophic = nutrition).

   Due to eutrophication the lakes get invaded by algal blooms. These algal species grow very fast by rapidly using up the nutrients. They are often toxic and badly affect the food chain. The algal species quickly complete their life cycle and die, thereby adding a lot of dead organic matter. The fishes are also killed and there is a lot of dead matter that starts getting decomposed. Oxygen is consumed in the process of decomposition and very soon the water gets depleted of dissolved oxygen. This further affects aquatic fauna and ultimately anaerobic conditions are created where only anaerobic bacteria can survive many of which are known to be pathogenic. Thus, due to excessive use of fertilizers in the agricultural fields the lake ecosystem gets degraded. This shows how an unmindful action can have far reaching consequences.

3. **Pesticide related problems:** Thousands of types of pesticides are used in agriculture. The first generation pesticides include chemicals like sulphur, arsenic, lead or mercury to kill the pests. DDT (Dichlorodiphenyl trichloroethane) whose insecticidal properties were discovered by Paul Mueller in 1939 belongs to the second generation pesticides. After 1940, a large number of synthetic pesticides came into use. Although these pesticides have gone a long way in protecting our crops from huge losses occurring due to pests, yet they have a number of side-effects, as discussed below:

   (*a*) **Creating resistance in pests and producing new pests:** Some individuals of the pest species usually survive even after pesticide spray. The survivors give rise to highly resistant generations. About 20 species of pests are now known which have become immune to all types of pesticides and are known as **"Super pests".**

(*b*) **Death of non-target organisms:** Many insecticides are broad spectrum poisons which not only kill the target species but also several non-target species that are useful to us.

(*c*) **Biological magnification:** Many of the pesticides are non-biodegradable and keep on accumulating in the food chain, a process called biological magnification. Since human beings occupy a high trophic level in the food chain, they get the pesticides in a bio-magnified form which is very harmful.

4. **Waterlogging:** Over irrigation of croplands by farmers for good growth of their crop usually leads to waterlogging. Inadequate drainage causes excess water to accumulate underground and gradually forms a continuous column with the water table. Under water-logged conditions, pore-spaces in the soil get fully drenched with water and the soil-air gets depleted. The water table rises while the roots of plants do not get adequate air for respiration. Mechanical strength of the soil declines, the crop plants get lodged and crop yield falls.

   In Punjab, extensive areas have become water-logged where adequate canal water supply or tube-well water encouraged the farmers to use it over-enthusiastically leading to waterlogging problem.

   Preventing excessive irrigation, sub-surface drainage technology and bio-drainage with trees like *Eucalyptus* are some of the remedial measures to prevent waterlogging.

5. **Salinity problem:** At present one third of the total cultivable land area of the world is affected by salts. In India about seven million hectares of land are estimated to be salt-affected which may be saline or sodic. Saline soils are characterized by the accumulation of soluble salts like sodium chloride, sodium sulphate, calcium chloride, magnesium chloride etc. in the soil profile. Their electrical conductivity is more than 4 dS/m. Sodic soils have carbonates and bicarbonates of sodium, the pH usually exceeds 8.0 and the exchangeable sodium percentage (ESP) is more than 15%.

A major cause of salinization of soil is excessive irrigation with poor quality (saline) water. About 20% of the world's croplands receive irrigation with canal water or ground water which unlike rainwater often contains dissolved salts. Under dry climates, the water evaporates leaving behind salts in the upper soil profile (Fig. 2.2).

Thousands of hectares of land area in Haryana and Punjab are affected by soil salinity and alkalinity. Salinity causes stunted plant growth and lowers crop yield. Most of the crops cannot tolerate high salinity.

The most common method for getting rid of salts is to flush them out by applying more good quality water to such soils. Another method is laying underground network of perforated drainage pipes for flushing out the salts slowly known as subsurface drainage.

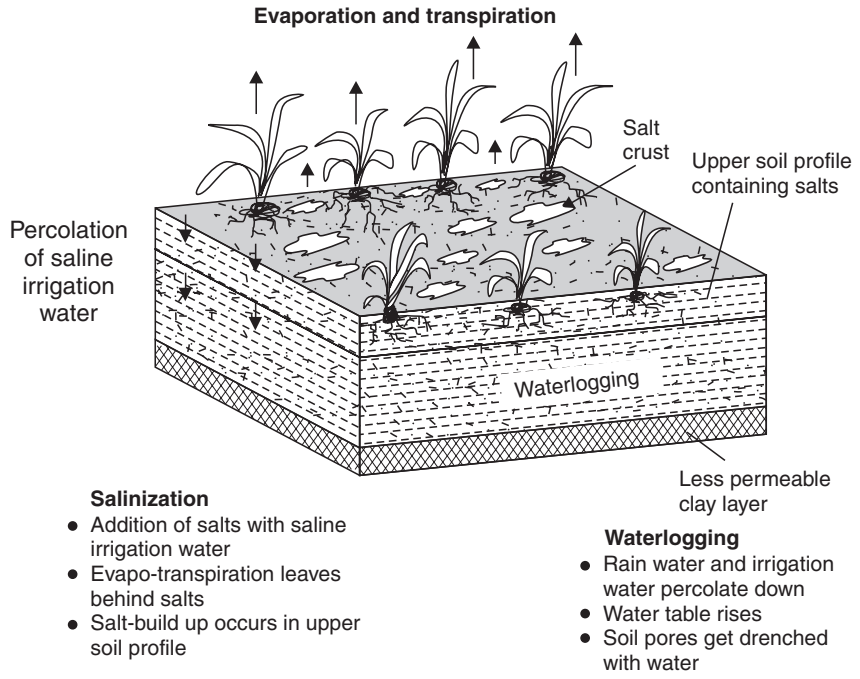

Evaporation and transpiration
Salt crust
Upper soil profile containing salts
Percolation of saline irrigation water
Waterlogging
Less permeable clay layer
Salinization
• Addition of salts with saline irrigation water
• Evapo-transpiration leaves behind salts
• Salt-build up occurs in upper soil profile
Waterlogging
• Rain water and irrigation water percolate down
• Water table rises
• Soil pores get drenched with water

Fig. 2.2. Salinization and waterlogging.

2.3.2 Effect of Housing

With increasing population growth, there has been a global shift of population from rural to urban centres. According to population Reference Bureau, 48% of the world population lives in urban areas now. Generally, towns with populations of 2000 or more are considered urban. Urban population is much higher (75%) in developed nations and about 38% of total population of developing nations lives in urban areas. Housing and infrastructure facilities is a major challenge in urban areas, where space is limited. Provision of water, sewage system, educational and medical facilities, transportations and housing to the influx of people from rural to urban areas is a big task.

Production and usage of practically all types of building materials during construction and demolition have some impact on the environment in one way or the other. Extraction and processing of building material is associated with energy consumption and waste generation, which vary depending upon the type of the building. Local materials used for building have less environmental implications in terms of energy use and waste production. The quality of building material chosen for construction needs to be assessed from the point of view of environmental impacts. Production and use of building materials have the following environmental impacts:

(*i*) Energy consumption and related impacts.

(*ii*) Physical degradation of environment and loss of top fertile soil.

(*iii*) Depletion of natural resources and biodiversity due to deforestation.

(*iv*) Gaseous emissions causing global warming and acid rains.

(*v*) Toxic emissions and health effects.

(*vi*) Occupational health hazards.

The major environmental implications of housing/building are discussed here.

(*i*) **Energy consumption during building and construction:** Energy consumption is an important aspect of construction. Energy is required for extraction of minerals such as iron ores, bauxite etc. Energy is also required for transportation, processing, fabrication and installation during construction, refurbishment and demolition of buildings.

The most important measure of environmental impact of a building material is **'embodied energy'** or **'capital energy'**. **Embodied energy is defined as the amount of energy used to produce a unit weight of the material.**

Based upon the impacts, environmental profiles of various types of building materials are now available. In relative environmental performance rating system, simple grades like A, B, C... etc., are assigned based on their associated variety of environmental impacts like mineral and water extraction, fossil fuel depletion, emissions of pollutants, toxicity, role in climate change etc.

The embodied energy of a material increases with increase in the number of processes it undergoes. The associated waste production also increases accordingly. For this reason, the choice of such eco-friendly materials is necessary which are as close to nature as possible and also nearer to the construction site; so that energy consumption for transportation, processing and transforming is minimal. The cost and eco-friendliness could also be improved by using recycled material. For instance, embodied energy of an aluminium-framed window will be different if made from the recycled metal or from its ore. The type of the material used is also equally important. Embodied energy of an aluminium-framed window would be definitely higher than that of a timber-framed window, as the latter involves less processing and is natural. Also, the latter would be more eco-friendly as it does not give CO_2 emissions for processing.

Transportation of the building material from production to sale, and from market to construction site adds to the embodied energy of the material. Emissions arising from the use of fuels in vehicles add to global warming and various noxious gases emitted lead to serious health problems. Another important factor for consideration of eco-friendly material is the maintenance requirement and life-span of the building.

Building materials that contribute to embodied energy are cement, concrete, bricks, steel, aluminium, timber, glass, plaster etc., which are generally used in all types of buildings. Metals and plastics have very high embodied energy. Their use in small quantities like that in joints or fixtures may, however, be useful. Thus, selection of a proper building material must be given due consideration. The embodied energy of plastics is very high as these are derived from petroleum involving energy intensive processing.

(*ii*) **Resource depletion and loss of biodiversity:** Timber, is an eco-friendly building material. But, indiscriminate cutting of forests for timber production has far reaching environmental consequences. It is therefore necessary that timber production should be based on a sustainable strategy of forest management. Timber production based on '*selective cutting practice*',

ensuring replacement of cut trees by fresh plantations, can take care of forest sustainability. There should also be a scheme to certify that the wood being used for building has been obtained from a sustainable forest.

An important point worth mentioning here is that if timber is produced by cutting down rainforests, it would not be possible to substitute the cut trees by similar species. The tropical rainforests have evolved over a period of millions of years with complex biodiversity, which has intricate mechanism of ecosystem stability and regulation. Loss of biodiversity or replacement of a complex heterogeneous rainforest by some simple fast growing tree species will cause irrepairable damage to the ecosystem and the environment. While selecting an eco-friendly building material, like timber from a rainforest, such important issues must be considered.

Even when timber is otherwise obtained from a far-off place, its eco-friendliness diminishes because of the energy used in transportation, thereby enhancing its embodied energy. Many a times timber is treated with chemicals to prevent its rotting and decay. Use of such a timber as a building material will reduce its eco-friendliness due to toxic nature of the chemicals used in the treatment. Use of synthetic organic paints are environmentally more harmful. These can be substituted by water-based natural pigments, stains or waxes. Thermal insulators (like recycled paper, wool or cork), earth wall, straw bale construction should be preferred if space permits and rough finishes are not inhibitive. Glazed coatings too save energy.

(*iii*) **Pollution apects of building:** Several building materials continue to affect the indoor air quality. These materials used as solvents, finishes and cleansers for maintenance and protection of building materials can cause 'sick building syndrome'.

Production of plastics is also associated with generation of the greenhouse gas namely, carbon dioxide (CO_2), volatile organic compounds (VOCs) and polyvinyl chloride (PVC), which are harmful because of global warming potential of CO_2 and health related problems of the latter two. Disposal of PVCs is a major problem. However, plastics have a positive aspect that these are derived from wastes of petroleum production.

Manufacturing of metals from their ores has several environmental impacts. In the recycling of metals harmful chemicals dioxins are produced, which are carcinegenic (cancer causing) in nature.

Some insulating materials are made from non-renewable petroleum resources, while some use chlorofluorocarbons (CFCs). During demolition, their safe recovery is difficult. Release of CFCs in the atmosphere would enhance the global warming problem. Asbestos, which has been quite in use in buildings is now known to be very harmful for our health and not recommended now. Even during demolition of existing buildings, recovery of asbestos should be carried out very carefully.

2.3.3 Environmental Impacts of Mining

The fact that reserves of mineral resources in our earth's crust or in the ocean are limited is not so significant as compared to the environmental concern arising from the impacts of extraction and processing of these minerals during mining and smelting.

Mining is done to extract minerals (or fossil fuels) from deep deposits in soil by using **sub-surface mining** or from shallow deposits by **surface mining**. The former method is more destructive, dangerous and expensive including risks of occupational hazards and accidents.

Surface mining can make use of any of the following three types:

(*a*) *Open-pit mining* in which machines dig holes and remove the ores (*e.g.,* copper, iron, gravel, limestone, sandstone, marble, granite).

(*b*) *Dredging* in which chained buckets and draglines are used which scrap up the minerals from under-water mineral deposits.

(*c*) *Strip mining* in which the ore is stripped off by using bulldozers, power shovels and stripping wheels (*e.g.,* phosphate rocks).

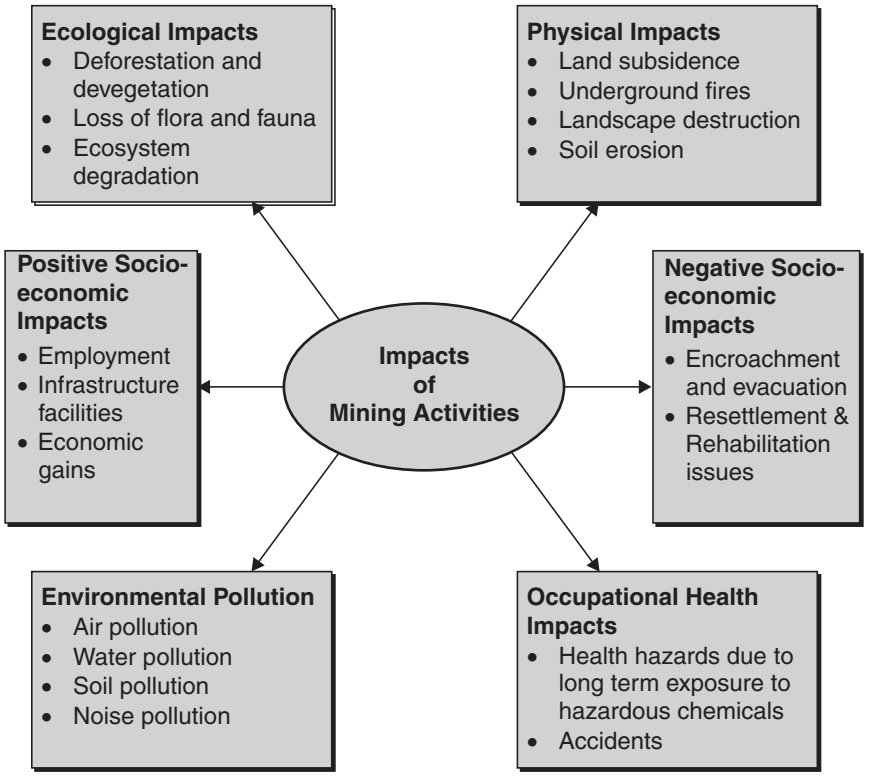


Fig. 2.3. Impacts of mining activities.

The environmental damage caused by mining activities depicted in Fig. 2.3 are discussed below:

(*i*) **Devegetation and defacing of landscape:** The topsoil as well as the vegetation are removed from the mining area to get access to the deposit. While large scale deforestation or devegetation leads to several ecological losses, the landscape also gets badly affected. Huge quantities of debris and tailings alongwith big scars and disruptions spoil the aesthetic value of the region and make it prone to soil erosion.

(*ii*) **Subsidence of land:** This is mainly associated with underground mining. Subsidence of mining areas often results in tilting of buildings, cracks in houses, buckling of roads, bending of rail tracks and leaking of gas from cracked pipe-lines leading to serious disasters.

(*iii*) **Groundwater contamination:** Mining disturbs the natural hydrological processes and also pollutes the groundwater. Sulphur, usually present as an impurity in many ores is known to get converted into sulphuric acid through microbial action, thereby making the water acidic. Some heavy metals also get leached into the groundwater and contaminate it posing health hazards.

(*iv*) **Surface water pollution:** The acid mine drainage often contaminates the nearby streams and lakes. The acidic water is detrimental to many forms of aquatic life. Sometimes radioactive substances like uranium also contaminate the water bodies through uranium mine wastes and kill aquatic animals. Heavy metal pollution of water bodies near the mining areas is a common feature causing health hazards.

(*v*) **Air pollution:** In order to separate and purify the metal from other impurities in the ore, smelting is done which emits enormous quantities of air pollutants damaging the vegetation nearby and has serious environmental health impacts. The suspended particulate matter (SPM), SOx, soot, arsenic particles, cadmium, lead etc. shoot up in the atmosphere near the smelters and the public suffers from several health problems.

(*vi*) **Occupational health hazards:** Most of the miners suffer from various respiratory and skin diseases due to constant exposure to the suspended particulate matter and toxic substances. Miners working in different types of mines suffer from asbestosis, silicosis, black lung disease etc.

Statistical data show that, on an average, there are 30 non-fatal but disabling accidents per ton of mineral produced and one death per 2.5 tons of mineral produced.

In order to minimize the adverse impacts of mining it is desirable to adopt eco-friendly mining technology. The low-grade ores can be better utilized by using **microbial leaching technique.** The bacterium *Thiobacillus ferroxidans* has been successfully and economically used for extracting gold embedded in iron sulphide ore. The ores are inoculated with the desired strains of bacteria, which remove the impurities (like sulphur) and leave the pure mineral. This biological method is helpful from economic as well as environmental point of view.

Restoration of mined areas by re-vegetating them with appropriate plant species, stabilization of the mined lands, gradual restoration of flora, prevention of toxic drainage discharge and conforming to the standards of air emissions are essential for minimizing environmental impacts of mining.

2.3.4 Effects of Industrialization

The most serious impact of industrialization is environmental pollution that has affected our land, water and air. Major rivers of the world have suffered colossal losses due to water pollution. Many important rivers have been converted into open severs. Even the groundwater is getting polluted due to illegal drilling of industrial waste water. Toxic gases and particulate matter from industrial emissions and vehicular exhaust have polluted the atmosphere. Release of greenhouse gases into the atmosphere has caused enhanced global warming. Release of CFC's has been responsible for depletion of protective ozone layer in the stratosphere, which makes our earth more prone to exposure of the harmful UV radiations.

Release of oxides of nitrogen and sulphur from power plants and industries is responsible for causing acid rain in many regions of the world. Contamination of the land with toxic heavy metals is

rendering it unproductive. Movement of heavy metals and pesticides through food chain has become a major cause of alarm for human health as well. All pollution aspects are being discussed separately in Chapter 6.

Human behaviour and the technological advances have not only caused regional (localized) impacts as discussed in the preceding section but have also resulted in global environmental disturbances. Technological advancement coupled with improved life style has resulted in production and emission of undesirable substances into the environment which are causing global environmental problems such as acid rain, ozone layer depletion, global warming and climate change.

2.3.5 Effects of Transportation

Movement of materials and human beings are being carried out in several ways using land, water as well as air as the medium of transport. In 1800, the steam engines fitted on to self-propelled vehicles were a major way of transport for both land and water. As 1900s progressed, rail transport gradually gave way to a large extent to airplanes, automobiles, buses and trucks.

In the modern era, private transport, commuting and relatively short distance travel is mainly by automobiles. The widespread use of automobiles has affected our environment in a substantial manner. Some of the major, environmental effects of transport on environment are as follows:

(*i*) Conversion of vast areas of agricultural land and wild-life habitats have been converted into sub-urban housing, as greater mobility has been made possible with increased automobile use.

(*ii*) Land is being used for building highways and there is loss of fertile top soil during construction of highways.

(*iii*) Landslide occurrence has increased as construction of roads clears large forested areas in the fragile mountainous areas.

(*iv*) Automobiles lead to air pollution due to vehicular emissions like carbon monoxide, lead (in case of leaded petrol), and volatile organic compounds.

(*v*) Noise pollution is a major problem arising due to transport activities.

(*vi*) Many aircrafts are releasing oxides of nitrogen that are greenhouse gases, responsible for climate change.

(*vii*) Widespread use of private automobiles has enormously increased the consumption of petrol, which has limited reserves.

I. QUESTIONS

1. Discuss how human activities related to food and shelter have affected our environment.
2. What are the major impacts of economic growth on environment?
3. What are different types of mining and how do mining activities influence our environment?
4. Discuss environmental impacts of transportation.

II. OBJECTIVE TYPE QUESTIONS

(A) FILL IN THE BLANKS

1. The average minimum caloric intake on a global scale is ..... calories/day.
2. People consuming less than 2000 calories are called ..... and those having protein deficiency are said to suffer from ..... .
3. Sustainable development ensuring equitable share of resources for economic growth of both the poor and the rich is expressed as ..... equity.
4. Nitrate concentrations exceeding 25 mg/L in water cause the health hazard ..... .
5. Pests which become immune to all types of pesticides are called. ..... .
6. Over nourishment of lakes due to addition of excessive nitrogen and phosphorus is knwon as ..... .
7. Accumulation of non-biodegradable substances along with food chain is called ..... .
8. Accumulation of soluble salts like sodium chloride in the soil profile make the soil ..... .
9. Exchangeable sodium percentage is greater than ..... % in sodic soils.
10. The amount of energy used to produce a unit weight of a material is called ..... energy.

(B) CHOOSE THE CORRECT ANSWER

1. 'Blue baby syndrome' is caused by contamination of water due to:
   (*a*) Phosphates (*b*) Sulphur
   (*c*) Arsenic (*d*) Nitrates.
2. Eutrophicated lakes are characterised by:
   (*a*) Hydrophytes (*b*) Algal blooms
   (*c*) Froth and foam (*d*) Black colour.
3. Over-irrigation without proper drainage leads to:
   (*a*) Water logging (*b*) Salinization
   (*c*) Both *a* and *b* (*d*) None of these.
4. Soils rich in carbonates and bicarbonates are
   (*a*) Saline (*b*) Acidic
   (*c*) Sodic (*d*) All of these.
5. Which of the following is the best ecofriendly building material?
   (*a*) Timber (*b*) Synthetic organic paints
   (*c*) Aluminium (*d*) Earth-wall.

(C) WRITE TRUE OR FALSE

1. 'Built environment' should include provisions for comfort of inhabitants along with balanced ecological elements. (True/False)
2. Economic growth over the years has narrowed down the disparity between developed and developing nations. (True/False)

3. Agriculture of 'Slash and burn type' has led to loss of forest land. (True/False)

4. Monoculture helps in spread of a disease rapidly, thus destroying the whole crop. (True/False)

5. A town with a population of 500 or more is considered urban. (True/False)

6. Microbial leaching is a technique of smelting of good-quality mineral ores. (True/False)

7. Construction of roads in mountainous areas have reduced the occurrence of landslides. (True/False)

8. Some aircrafts can play a role in climate change due to emissions of greenhouse gases like oxides of nitrogen. (True/False)

3

Environmental Impact Assessment and Sustainable Development

3.1 INTRODUCTION

The present era of fast development and growth is aimed at raising the quality of human life by providing greater opportunities for employment, better provisions of basic amenities and comforts, healthy environment ensuring physical and mental well-being of humans. Also growth and development lead to several environmental problems like pollution of the air, water and soil, depletion of natural resources, energy crisis, occupational health problems, and global problems like climate change, ozone layer depletion, and loss of biodiversity. Thus, development is bound to have certain environmental impacts. It was about 40 years back when it was realized that before a development project is started, prediction and assessment of its impacts should be done, so that measures could be taken to minimize those impacts. This concept was formulated as a methodical procedure known as **Environmental Impact Assessment (EIA).**

Further, for achieving the goals of real improvement in the quality of human life, development should be based on sustainability principles. Thus, **sustainable development** aims at growth with judicious use of resources and causing minimum damage to the environment.

3.2 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

Environmental Impact Assessment (EIA) is a procedure to plan some developmental activity with well-defined environmental goals so that damage due to the activity both during developmental stage and production stage have minimum impact on the natural system and the population in the area.

The National Environmental Policy Act (NEPA) U.S.A. in 1969 first of all provided the guidelines for environmental impact assessment through Council for Environmental Quality (CEQ).

In India, the gazette notification on EIA was issued in 1994 vide which the Ministry of Environment and Forests provided guidelines for project proponents to have EIA and prepare an Environmental Impact Statement prior to clearance of the project.

3.2.1 Goals of EIA

(*i*) To fulfill the responsibilities towards the coming generations as trustees of environment.
(*ii*) To assure safe, healthy, productive, aesthetically as well as culturally pleasing surroundings.
(*iii*) To provide widest range of beneficial uses of environment without degradation or risk to health.
(*iv*) To preserve historical, cultural and natural heritage.
(*v*) To achieve a balance between population and resource use for a good standard of living.
(*vi*) To ensure sustainable development with minimal environmental degradation.

3.2.2 Environmental Impact Statement (EIS)

The EIS is prepared by the project proponents at the time of submission of the proposal, which is known as the *draft EIS.* After evaluation and review by the Impact Assessment Agency, the *final EIS* is prepared.

The following points are usually incorporated while preparing the EIS:

- Effect on land including land degradation and subsistence.
- Deforestation and compensatory afforestation.
- Air pollution and dispersion along with possible health effects.
- Water pollution including surface water and ground water pollution.
- Noise pollution due to the project.
- Loss of flora and fauna due to the project during construction.
- Socio-economic impacts including displacement of native people, cultural loss and health aspects.
- Risk analysis and disaster management plan.
- Recycling and reduction of waste.
- Efficient use of inputs including energy and matter.

EIA is done with an aim to select the best alternative through which adverse impact on the environment can be nullified or minimized without compromising with the economic and social benefits of the developmental project.

Four types of alternatives are considered:

(*i*) **Alternative technologies** providing options with maximum energy efficiency and minimal wastage.
(*ii*) **Alternative mitigating or controlling mechanisms** through which recycling of by-products or reduction of emissions can take place.
(*iii*) **Alternate phasing** to work out if phasing of the project is possible instead of one stroke development to avoid drastic impact.
(*iv*) **Alternate site** for the proposed project.

However, the most important alternative taken into consideration in EIA is the impact assessment at alternative sites *i.e.,* which of the site I or II or III located in different natural area would have the least impact of the development project, and that site is selected for the development project.

Thus, the main purpose of EIA is precisely to estimate the type and level of damage caused to natural environment in a well-defined time scale so that remedial measures can be initiated on those aspects requiring action at the right time.

3.2.3 EIA Methodology

The basic steps followed in EIA are screening, scoping, base line data, impact identification, prediction, evaluation, mitigation, EIS preparation, review and environment audit, involving public participation at various stages, as shown in Fig. 3.1.

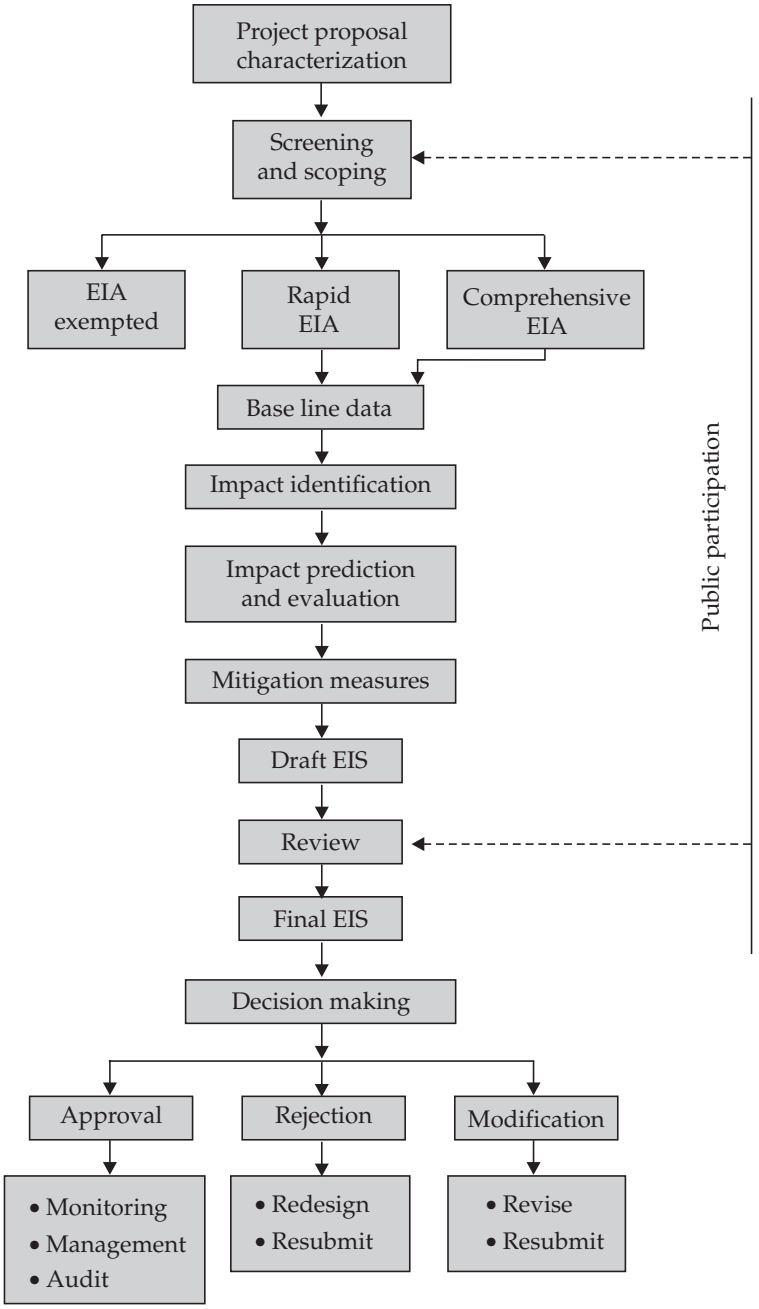


Fig. 3.1. EIA methodology flow-chart.

(*i*) **Screening** is done to see whether the project needs an EIA for clearance or not. Further, there are some prohibited areas where generally development projects are not allowed *e.g.,* Coastal Regulation Zone (CRZ), Dahanu Taluka in Maharashtra, Aravalli range, Reserve forests etc.

(*ii*) **Scoping** involves determination of the extent of EIA required for the project. Depending upon the project, basically two types of EIA may be carried out. When the EIA report is based on a single season data (other than monsoon period), it is called *rapid EIA*. When the EIA report is based on detailed seasonal data, it is called *comprehensive EIA*.

(*iii*) **Baseline data** gives a holistic picture of the overall environmental setting of the project location showing any significant environmental items prior to initiation of the action; any potentially critical environmental changes and information about the site to the decision makers and reviewers, who might be unfamiliar with the general location of the project area.

The following environmental parameters are usually considered while preparing the baseline data:

(*a*) Site location and topography.

(*b*) Regional demography – population distribution within 10 and 50 kilometer radius; land-use and water-use pattern.

(*c*) Regional landmarks like historical and cultural heritage in the area. For this archaeological or state register can be checked.

(*d*) Geology – Groundwater and surface water resources are quantified; water, quality, pollution sources etc. are studied.

(*e*) Hydrology – Groundwater and surface water resources are quantified; water, quality, pollution sources etc. are studied.

(*f*) Meteorology – Temperature extremes, wind speed and direction, dew point, atmospheric stability, rainfall, storms etc. are recorded.

(*g*) Ecology – The flora, fauna, endangered species, successional stage etc. are enlisted.

For a particular project, some of the parameters may be important while for others, some other parameters could be important.

(*iv*) **Impact identification:** It includes the details of project characters and baseline environmental characteristics to ensure the identification of full range of environmental impacts.

During identification process, the positive and negative, direct and indirect significant and insignificant impacts are considered.

(*v*) **Impact prediction:** Here magnitude of changes going to occur due to the project are predicted by using mathematical models or mass balance models.

(*vi*) **Impact evaluation:** Impact evaluation is done by considering the costs and benefits of the project. Long-term effects and side-effects of the project are also evaluated. Indirect valuation of environmental parameters are also done. *e.g.* loss of a rare species, degradation of a lake etc.

(*vii*) **Mitigation:** Once the impacts are predicted and evaluated, mitigation measures are to be suggested to avoid, reduce or rectify the adverse changes due to the project.

Review and a draft impact statement is prepared at this stage.

(*viii*) **Decision analysis:** Public participation is involved by arranging group discussion or by adopting questionnaire method to arrive at a decision about the project and its evaluation.

(*ix*) **Environmental impact statement (EIS):** Based on the data obtained and review suggestions a final EIS is prepared as per the format provided by the Ministry of Environment and Forests in our country.

The EIS clearly mentions the objectives of the project, its environmental impacts, impacts that are unavoidable, mitigation measures to minimize the impacts, alternatives to the proposed action etc.

(*x*) **Environmental audit:** It compares the impacts predicted in EIS before the project was started and actual impacts after implementation of the project.

3.3 SUSTAINABLE DEVELOPMENT

Human beings live in both natural and social world. Our technological development has strong impacts on the natural as well as the social components. When we talk of development, it cannot be perceived as development only for a privileged few who would have a high standard of living and would derive all the benefits. Development also does not mean an increase in the GNP (Gross National Product) of a few affluent nations. Development has to be visualized in a holistic manner, where it brings benefits to all, not only for the present generation, but also for the future generations.

There is an urgent need to inter-link the social aspects with development and environment. In this unit we shall discuss various social issues in relation to environment.

Sustainable development is defined as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." This definition was given in Brundtland Commission Report, ''Our Common Future'', by the Norwegian Prime Minister, G.H. Brundtland, who was also the Director of World Health Organisation (WHO). Today sustainable development has become a buzz word and hundreds of programmes have been initiated in the name of sustainable development. If you want to test whether or not a proposal will achieve the goals of sustainability just try to find out the following:

– Does it protect our biodiversity?

– Does it prevent soil erosion?

– Does it slow down population growth?

– Does it increase forest cover?

– Does it cut off the emissions of CFC, SO_x, NO_x and CO_2?

– Does it reduce waste generation and does it bring benefits to all?

These are only a few parameters for achieving sustainable growth.

Until now development has been human-oriented, that too mainly, for a few rich nations. They have touched the greatest heights of scientific and technological development, but at what cost? The air we breathe, the water we drink and the food we eat have all been badly polluted. Our natural resources are just dwindling due to over exploitation. If growth continues in the same way, very soon we will be facing a "doom's day"—as suggested by Meadows and co-workers in their world famous academic report "***The Limits to Growth***". This is unsustainable development which will lead to a collapse of the inter-related systems of this earth.

Although the fears about such unsustainable growth and development started in 1970's, yet a clear discussion on sustainable development emerged on an international level in 1992, in the **UN Conference on Environment and Development (UNCED)**, popularly known as The **Earth Summit**, held at Rio de Janeiro, Brazil. The Rio Declaration aims at "*a new and equitable global partnership through the creation of new levels of cooperation among states ….*" Out of its five significant agreements **Agenda-21** proposes a global programme of action on sustainable development in social, economic and political context for the 21st century.

This was followed by **UN World Summit on Sustainable Develpment (WSSD)** in Johannesburg, South Africa in 2002 which emphasized on national strategies for sustainable development.

The key aspects for sustainable development are:

(*a*) **Inter-generational equity:** This emphasizes that we should minimize any adverse impacts on resources and environment for future generations *i.e.* we should hand over a safe, healthy and resourceful environment to our future generations. This can be possible only if we stop over-exploitation of resources, reduce waste discharge and emissions and maintain ecological balance.

(*b*) **Intra-generational equity:** This emphasizes that the development processes should seek to minimize the wealth gaps within and between nations. The Human Development Report of United Nations (2001) emphasizes that the benefits of technology should seek to achieve the goals of intra-generational equity. The technology should address the problems of the developing countries, producing drought tolerant varieties for uncertain climates, vaccines for infectious diseases, clean fuels for domestic and industrial use. This type of technological development will support the economic growth of the poor countries and help in narrowing the wealth gap and lead to sustainability.

Measures for Sustainable Development: Some of the important measures for sustainable development are as follows:

(*i*) **Using appropriate technology** is one which is locally adaptable, eco-friendly, resource-efficient and culturally suitable. It mostly involves local resources and local labour. Indigenous technologies are more useful, cost-effective and sustainable. Nature is often taken as a model, using the natural conditions of that region as its components. This concept is known as "*design with nature*".

The technology should use less of resources and should produce minimum waste.

(*ii*) **Reduce, Reuse, Recycle approach:** The **3-R approach** advocating minimization of resource use, using them again and again instead of passing it on to the waste stream and recycling the materials goes a long way in achieving the goals of sustainability. It reduces pressure on our resources as well as reduces waste generation and pollution.

(*iii*) **Promoting environmental education and awareness:** Making environmental education the centre of all learning process will greatly help in changing the thinking pattern and attitude of people towards our earth and the environment. Introducing subject right from the school stage will inculcate a feeling of belongingness to earth in small children. 'Earth thinking' will gradually get incorporated in our thinking and action which will greatly help in transforming our lifestyles to sustainable ones.

(*iv*) **Resource utilization as per carrying capacity:** Any system can sustain a limited number of organisms on a long-term basis which is known as its **carrying capacity**. In case of human

beings, the carrying capacity concept becomes all the more complex. It is because unlike other animals, human beings, not only need food to live, but need so many other things to maintain the quality of life.

Sustainability of a system depends largely upon the carrying capacity of the system. If the carrying capacity of a system is crossed (say, by over exploitation of a resource), environmental degradation starts and continues till it reaches a point of no return.

Carrying capacity has two basic components:

- **Supporting capacity** *i.e.* the capacity to regenerate
- **Assimilative capacity** *i.e.* the capacity to tolerate different stresses.

In order to attain sustainability it is very important to utilize the resources based upon the above two properties of the system. Consumption should not exceed regeneration and changes should not be allowed to occur beyond the tolerance capacity of the system.

(*v*) **Improving quality of life including social, cultural and economic dimensions:** Development should not focus just on one section of already affluent people. Rather it should include sharing of benefits between the rich and the poor. The tribal, ethnic people and their cultural heritage should also be conserved. Strong community participation should be there in policy and practice. Population growth should be stabilized.

Thus sustainable development can occur by integrating social, scientific and ecological dimensions at regional and global level, as illustrated in Fig. 3.2.

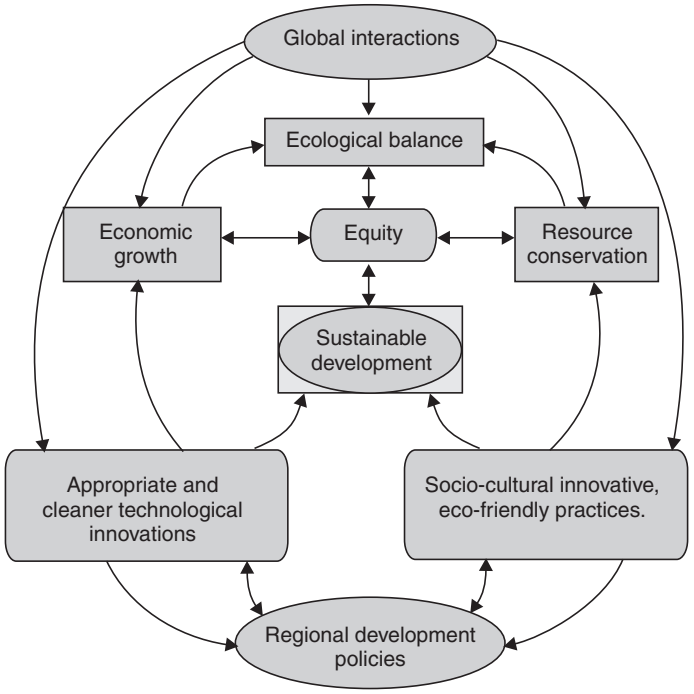


Fig. 3.2. Multidimensional model for sustainable development.

Sustainable development is possible by considering the earth and its resources as common for all. Participatory role of public and different nations for evolving technological innovations and conservationist life style is equally important to achieve economic growth, ecological balance, equity and resource conservation.

I. QUESTIONS

1. What is Environmental Impact Assessment? Why should we have EIA of any developmental project?
2. What are the goals of EIA?
3. Draw a flow chart of EIA methodology.
4. What is Environmental Impact Statement (EIS)? What are the important points considered for preparing the EIS?
5. What is the significance of Environmental audit?
6. Define sustainable development? Why is it necessary?
7. What are inter-generational and intra-generational equity?
8. Define carrying capacity of a system.
9. What is included in the baseline data?

II. OBJECTIVE TYPE QUESTIONS

(A) FILL IN THE BLANKS

1. EIA guidelines were first of all provided by ..... .
2. ..... is an important step in EIA which helps to avoid, reduce or rectify the adverse changes due to the project.
3. The concept of sustainable development was given by ..... .
4. The Earth Summit was held at .....
5. ..... is the capacity to tolerate different stresses.

(B) CHOOSE THE CORRECT ANSWER

1. Gazette notification on EIA is issued by
(*a*) Ministry of Sports
(*b*) Ministry of Human Resource Development
(*c*) Ministry of Finance
(*d*) Ministry of Environment and Forests.
2. EIA helps to
(*a*) achieve sustainable development
(*b*) reap environmental benefits without its degradation

(*c*) maintain balance between population and resources
(*d*) all of these.

3. Study of various atmospheric parameters is called
(*a*) Geology
(*b*) Hydrology
(*c*) Meteorology
(*d*) None of these.

4. UN Conference on Environment and Development (UNCED) is popularly known as
(*a*) Montreal protocol (*b*) Basel conference
(*c*) Earth summit (*d*) None of these.

5. Capacity of a system to sustain a maximum number of organism on a long-term basis is known as
(*a*) Buffering capacity (*b*) Carrying capacity
(*c*) Limited capacity (*d*) None of these.

(C) WRITE TRUE OR FALSE

1. Quality of life on this planet can be maintained by following the principles of sustainable development. (True/False)

2. EIA procedure takes care of projects during their production stage only. (True/False)

3. Environmental Impact Statement includes data on air pollution and water pollution only. (True/False)

4. Reduce, Reuse, Recycle approach will not make much difference in environmental protection. (True/False)

5. Agenda-21 was proposed during the Earth Summit held at Rio de Janeiro. (True/False)

4

Natural Resources

4.1 WATER RESOURCES

Water is an indispensable natural resource. Life on the earth could originate because of the presence of water. About 97% of earth's surface is covered by water. Water is essential for maintenance of life. Most of the animals and plants have 60–65% water in their bodies. Due to its unique properties water is of multiple uses for all living organisms. Water is absolutely essential for life. Most of the life processes take place in water contained in the body. Uptake of nutrients, their distribution in the body, regulation of temperature, and removal of wastes are all mediated through water. Human beings depend on water for almost every developmental activity. Water is used for drinking, irrigation, transportation, washing and waste disposal for industries and used as a coolant for thermal power plants. Water shapes the earth's surface and regulates our climate.

4.2 AVAILABILITY AND QUALITY ASPECTS

4.2.1 Water Availability

Although water is abundant on this earth, yet it is very precious. Out of the total water reserves of the world, about 97.4% is salty water (marine) and only 2.6% is fresh water. Even this small fraction of fresh water is not available to us as most of it is locked up in polar ice caps (1.98%) and just 0.6% is readily available to us in the form of groundwater and surface water (rivers and lakes), water in atmosphere and in the living organisms.

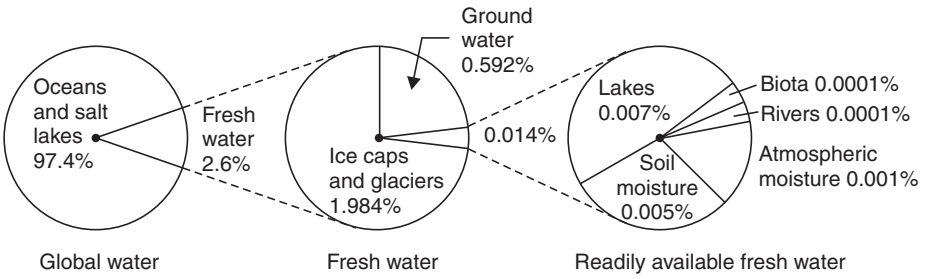


Fig. 4.1. Distribution of global water.

Oceans: Oceans are ultimate sinks for all types of water. About 97.4% of total water is present in oceans. Salt content of oceans is about 3.5%. Sea water is not fit for human consumption and other anthropogenic activities without desalination.

Glaciers and Ice: A major part of available approximately 2.6% of fresh water is locked up into glaciers and ice caps. These occur at high altitude or high latitude. Antarctic glacier contains approximately 85% of all the world's ice. About 10% is made by greenland ice-sheet and arctic ice. Rest 5% is in the form of snow on mountain peaks.

Groundwater

About 0.59% of the total water resources is in the form of groundwater and it is about 35–50 times that of surface water supplies. Till some time back groundwater was considered to be very pure. However, of late, even groundwater aquifers have been found to be contaminated by leachates from sanitary landfills etc.

A layer of sediment or rock that is highly permeable and contains water is called an **aquifer**. Layers of sand and gravel are good aquifers while clay and crystalline rocks (like granite) are not since they have low permeability. Aquifers may be of two types:

Unconfined aquifers which are overlaid by permeable earth materials and they are recharged by water seeping down from above in the form of rainfall and snow melt.

Confined aquifers which are sandwiched between two impermeable layers of rock or sediments and are recharged only in those areas where the aquifer intersects the land surface. Sometimes the recharged area is hundreds of kilometers away from the location of the well. Figure 4.2 shows the groundwater system. Groundwater is not static, it moves, though at a very slow rate of about a meter or so in a year.

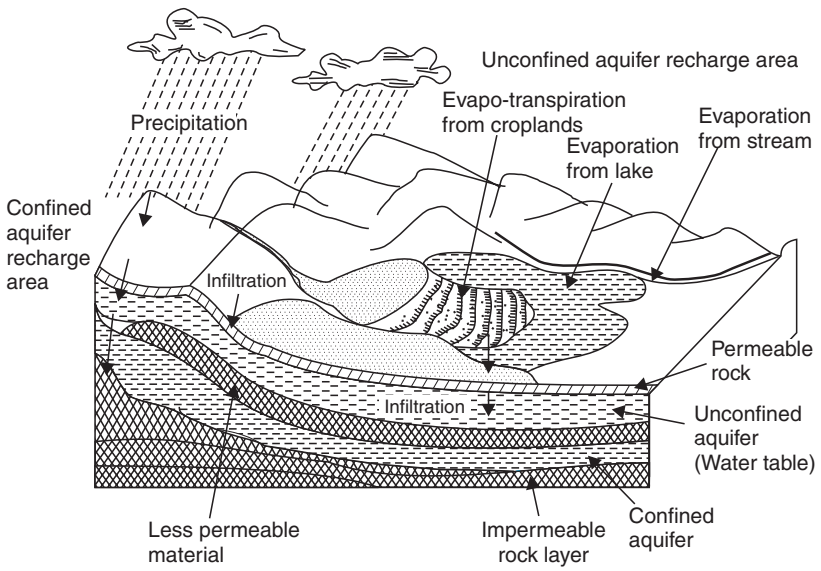


Fig. 4.2 The groundwater system. An unconfined aquifer (water table) is formed when water collects over a rock or compact clay. A confined aquifer is formed as sandwiched between two layers having very low permeability.

Effects of Groundwater Usage

(*i*) **Subsidence:** When groundwater withdrawal is more than its recharge, the sediments in the aquifer get compacted, a phenomenon known as *ground subsidence*. Huge economic losses may occur due to this phenomenon because it results in the sinking of overlying land surface. The common problems associated with it include structural damage in buildings, fracture in pipes, reversing the flow of sewers and canals and tidal flooding.

(*ii*) **Lowering of water table:** Mining of groundwater is done extensively in arid and semi-arid regions for irrigating crop fields. However, it is not advisable to do excessive mining as it would cause a sharp decline in future agricultural production, due to lowering of water table.

(*iii*) **Water logging:** When excessive irrigation is done with brackish water it raises the water table gradually leading to water-logging and salinity problems.

Surface Water

The water coming through precipitation (rainfall, snow) when does not percolate down into the ground or does not return to the atmosphere as evaporation or transpiration loss, assumes the form of streams, lakes, ponds, wetlands or artificial reservoirs known as surface water. The surface water is largely used for irrigation, industrial use, public water supply, navigation etc. A country's economy is largely dependent upon its rivers.

Water rich vs. Water poor countries

The top ten water rich countries are Iceland, Surinam, Guyana, Papua New Guinea, Gabon, Solomon Islands, Canada, Norway, Panama, and Brazil lying in the far north and have low evaporation losses.

The water poor countries include Kuwait, Egypt, United Arab Emirates, Malta, Jordan, Saudi Arabia, Singapore, Maldovia, Israel and Oman lying in the desert belt at about 15° to 25° latitude and some of them like Malta and Singapore are densely populated areas resulting in low per capita water.

Water in the rivers comes from precipitation, melting of snow and ice and groundwater seepage.

Lakes and ponds are shallow depressions in the earth. Some lakes are a few km in length. These are permanent or temporary water bodies. These suffer from the problem of siltation which may make them temporary in nature. Lakes and ponds contain more than 100 times the water present in all rivers and streams.

Swamps and marshes are important wetlands. These wetlands have the capacity to absorb surface run-off. These provide sufficient time for recharge of groundwater and also play an important role in hydrological cycle.

Soil moisture is held up in the soil capillaries and this water is useful for plant growth. **Atmosphere** contains about 0.001% of the total water on this earth. It forms a small proportion of total water available. Atmospheric water stays in the atmosphere for short duration as it gets distributed with air currents and falls as precipitation to replanish the terrestrial water bodies.

Hydrological Cycle:

The water we use keeps on cycling endlessly through the environment which we call as **Hydrological Cycle**. We have enormous resources of water on the earth amounting to about 1404 million km^3. The water from various moist surfaces evaporates and falls again on the earth in the form of rain or snow and passes through living organisms and ultimately returns to the oceans. Every year about 1.4 inch thick layer of water evaporates from the oceans, more than 90% of which returns to the oceans through the hydrological cycle. Solar energy drives the water cycle by evaporating it from various water bodies which subsequently return through rainfall or snow. Plants too play a very important role by absorbing the groundwater from soil and releasing it into the atmosphere by the process of transpiration.

Global distribution of water resources is quite uneven depending upon several geographic factors. Tropical rain forest areas receive maximum rainfall while the major world deserts occur in zones of dry, descending air (20–40° N and S) and receive very little rainfall.

4.2.2 Water Quality

Water is characterized by certain unique qualities which make it a marvellous resource:

(*i*) It exists as a liquid over a wide range of temperature *i.e.* from 0° to100°C.

(*ii*) It has the highest specific heat, due to which it warms up and cools down very slowly without causing shocks of temperature jerks to the aquatic life.

(*iii*) It has a high latent heat of vaporization. Hence, it takes a huge amount of energy for getting vaporized. That's why it produces a cooling effect as it evaporates.

(*iv*) It is an excellent solvent for several nutrients. Thus, it can serve as a very good carrier of nutrients, including oxygen, which are essential for life. But, it can also easily dissolve various pollutants and also becomes a carrier of pathogenic microorganisms.

(*v*) Due to high surface tension and cohesion it can easily rise to great heights through the trunk even in the tallest of the trees like *Sequoia*.

(*vi*) It has an anamolous expansion behaviour *i.e.* as it freezes, it expands instead of contracting and thus becomes lighter. It is because of this property that even in extreme cold, the lakes freeze only on the surface. Being lighter the ice keeps floating, whereas the bottom waters remain at a higher temperature and therefore, can sustain aquatic organisms even in extreme cold.

As water is a good solvent, it is prone to contamination by a variety of substances. Water bodies have been treated as sewers for industrial and municipal discharges. Deterioration of fresh water renders it unfit for drinking. Water treatment is done before domestic supply.

More than 90% of the population in the United State as also many European countries don't even bother whether the drinking water is safe or not. However, in the developing countries the first question a visitor asks is whether the drinking water is safe to drink. We quite often see most of such people carrying their own mineral water bottles. It is estimated that 80 per cent of sickness in the world is due to improper quantity or quality of drinking water. The most affected areas in the world are in Asia, Africa and Latin America. About 60% of babies born in the developing nations die of gastic disturbances. Millions of people are affected by schistosomiasis and filariasis. It is imperative to provide drinking water which is free from pathogens and other noxious substances which can cause sickness or disease.

Drinking water should

(*i*) be free from pathogens

(*ii*) have required salts and should not have high concentration of minerals and organic matter.

(*iii*) not have toxic chemicals

Drinking Water Standards. The drinking water standards are the values for each parameter beyond which water is considered unfit for drinking. These standards are given in table 4.1

Table 4.1. Drinking Water – Specification (BIS 10500: 1991)

Sl. No.	*Substance or characteristic*	*Requirement (Desirable limit)*	*Permissible limit in the absence of alternate source*
Essential Characteristics			
1.	Colour (Hazen units, Max)	5	25
2.	Odour	Unobjectionable	Unobjectionable
3.	Taste	Agreeable	Agreeable
4.	Turbidity (NTU. Max)	5	10
5.	pH Value	6.5 to 8.5	No relaxation
6.	Total hardness (as $CaCO_3$) mg/L, Max	300	600
7.	Iron (as Fe) mg/L, Max	0.3	1.0
8.	Chlorides (as Cl) mg/L, Max.	250	1000
9.	Residual free chlorine, mg/L, Min.	0.2	--
10.	Fluoride (as F) mg/L, Max	1.0	1.5
Desirable Characteristics			
11.	Dissolved solids mg/L, Max	500	2000
12.	Calcium (as Ca) mg/L, Max	75	200
13.	Magnesium (as Mg) mg/L, Max	30	100
14.	Copper (as Cu) mg/L, Max	0.05	1.5
15.	Manganese (as Mn) mg/L, Max	0.10	0.3
16.	Sulfate (as SO_4) mg/L, Max	200	400
17.	Nitrate (as NO_3) mg/L, Max	45	No relaxation
18.	Phenolic compounds (as $C_6 H_5OH$) mg/L, Max	0.001	0.002
19.	Mercury (as Hg) mg/L, Max	0.001	No relaxation

20.	Cadmium (as Cd) mg/L, Max	0.01	No relaxation
21.	Selenium (as Se) mg/L, Max	0.01	No relaxation
22.	Arsenic (as As) mg/L, Max	0.01	No relaxation
23.	Cyanide (as CN) mg/L, Max	0.05	No relaxation
24.	Lead (as Pb) mg/L, Max	0.05	No relaxation
25.	Zinc (as Zn) mg/L, Max	5	15
26.	Anionic detergents (as MBAS) mg/L, Max	0.2	1.0
27.	Chromium (as Cr^{6+}) mg/L, Max	0.05	No relaxation
28.	Polynuclear aromatic hydrocarbons (as PAH) g/L, Max	--	--
29.	Mineral oil mg/L, Max	0.01	0.03
30.	Pesticides mg/L, Max	Absent	0.001
31.	Radioactive materials		
	(*i*) Alpha emitters Bq/L. Max	--	0.1
	(*ii*) Beta emitters pci/L. Max	--	1.0
32.	Alkalinity mg/L, Max	200	600
33.	Aluminium (as Al) mg/L, Max	0.03	0.2
34.	Boron mg/L, Max	1	5

Bacteriological Examination

Water in Distribution System

Water in the distribution system, piped water, upto the consumer's level should have no coliform organisms. Since it is not ideally possible, therefore, the following standard in the water sample collected from distribution system is recommended (tested in accordance with IS 1622:1981)

(*a*) Throughout any year, 95 percent of samples should not contain any coliform organisms in 100 mL;

(*b*) No sample should contain *E. Coli* in 100 mL;

(*c*) No sample should contain more than 10 coliform organisms per 100 mL; and

(*d*) Coliform organisms should not be detectable in 100 mL of any two consecutive samples.

4.3 WATER BORNE AND WATER INDUCED DISEASES

Disease causing agents (pathogens) are infectious organisus which cause disease when these grow and multiply in the host. These organisms come from the waste of infected individuals which reach the municipal wastewater. Municipal water usually contains various types of bacteria, viruses, protozoans worms and other types of agents which cause various types of diseases of man and other animals. Contaminated water can cause water borne and water-induced and water-contact diseases.

Water borne diseases are caused by ingestion of pathogens. These pathogens can be ingested with contaminated drinking water, hands or utensils. Some of the waterborne diseased caused by bacteria or virus are cholera, bacterial dysentery, typhoid, polio, infectious hepatitis. Certain protozoans also cause diseases like amoebic dysentery, cryptosporidiosis, Giardiasis etc. Giardiasis is caused by **Giardia lamblia.** The cysts of **Giardia** pass through the faces of carrier humans/animals and can survive for many months in the environment.

Cholera is caused by a bacterium (**Vibrio cholerae**) and causes severe diarrhoea, vomitting which may cause cramps. Bacterial dysentery is caused by a bacterium (**Shigella dysenteriae**). The patient suffers from abdominal pain (due to infection of colon) and diarrhoea with mucus and blood in stools.

Enteritis is caused by bacterium (Clostridium perfringens). The small intestine develops inflammation which results in loss of appetite, abdominal cramps and diarrhoea. Typhoid is also a bacterial disease caused by (Salmonella typhi). The symptoms include headache, weakness, fever, rashes and sometime bleeding in intestines.

Infectious hepatitis is caused by virus (Hepatitis virus A). In this disease jaundice is caused due to liver inflammation. Other symptoms include headache, nausea, vomitting and loss of appetite.

Poliomyelitis is caused by virus (Poliovirus). The disease is characterised by sore throat, fever, diarrhoea, pain in limbs and back. Paralysis and atrophy of muscles can occur if infection spreads to spinal cord.

Cryptosporidiosis is caused by protozoan (Cryptosporidium sp.) The disease symptoms are diarrhoea and cramps. Symptoms last for upto 22 days.

Amoebic dysentery is caused by a protozoon (**Entamoeba histolytica).** Symptoms of the disease are abdominal pain. Due to infection of colon diarrhoea becomes painful. Mucus and blood are seen in stool.

WHO Report: 13 million deaths due to environmental exposure

The World Health Organisation in its report (2006) has emphasised that diseases can be prevented through healthy environment. More than 33 per cent of diseases in children below 5 yrs. are due to environmental exposures. About one quarter of diseases in the world are due to environmental exposures while it is one third in less developed countries.

Malaria and diarrhoea are the world's two biggest killer diseases of childhood. Other such diseases are due to infection of respiratory tract. These diseases can be prevented through better environmental management.

Safe storage of water, better hygienic environment, use of safer and cleaner fuels, increased safety measures at home and workplace and reduction and proper management of wastes and hazardous substances can reduce the environmental disease burden.

It is estimated that 94 per cent of diarrhoeal burden of disease comes from unsafe water, sanitation and hygiene and 41 per cent of lower respiratory infections come from indoor and outdoor air pollution.

There are some diseases which may occur without ingestion of pathogens with drinking water. These are called water-contact diseases and are spread by entry into the host of the parasite or its developmental stage from the contaminated water, *e.g.,* Schistosomiasis, Ancylostomiasis, Dracunculiasis.

There are other water related diseases which are caused by insect vector like mosquitoes which bread in the contaminated water *e.g.* dengue, filariasis, yellow-fever, malaria, onchocerciasis, trypanosomiasis etc. Some diseases are caused due to poor personal hygiene and skin and eye contact with contaminated water *e.g.* scabies, trachoma and other lice, tick and flea borne diseases.

Some diseases are induced by contaminated water. These water-induced diseases are due to the presence of arsenic, fluoride, nitrates from fertilizers, carcinogenic pesticides, heavy metals etc. The details of such diseases are given in water pollution chapter of unit III.

About 11 crore (1.1 billion) people, of which about 91% from Asia and Africa don't have access to good quality water. Contaminated water is responsible for about 80% of the infectious diseases. More than 50 lakh people die each year due to such diseases and more than 20 lakh people, most of them small children, die each year from diarrhoea caused by contaminated water.

Such diseases caused by contaminated water can be minimised or controlled by the following approach:

- Open defection should be avoided.
- Diapers should be disposed off properly.
- Hands should be washed before eating.
- Raw vegetables and fruits should be washed properly before eating.
- General sanitation be improved.
- Public health department should properly monitor and any outbreak of water borne diseases should be duly reported to concerned department.
- Media can help in disseminating information and status to general public.
- Education can spread awareness among people of different ages.

4.4 FLUORIDE PROBLEM IN DRINKING WATER

Fluoride is present in varying levels in almost all types of waters. Sea water contains about 1 mg/L, rivers and lakes less than 0.5 mg/L and ground water may have from low to high values depending upon nature of rock and fluoride bearing minerals in the bedrock. Fluoride may enter in the public water system from natural source *i.e.,* run-off from weathering of fluoride containing rocks and soils or leaching from soil to ground water. Industrial discharges may also contaminate water supply.

Requirement of fluoride: Some amount of fluoride is required in drinking water to prevent tooth decay. Therefore, fluoride is intentionally added to public drinking water supply where natural fluoride is low. Optimal level which can prevent tooth decay is from 0.7 to 1.2 mg/L.

Factors affecting intake of fluoride: Fluoride intake per person per day depends on fluoride concentration in drinking water and the amount of water taken by an individual per day. Water consumption increases with temperature, humidity, exercise, state of health and other factors including diet. Climatic conditions influence water intake by an individual. It is more near equator.

As per a rough estimate total daily fluoride intake in temperate climate would be approximately 0.6 mg per adult per day where no fluoride is added to drinking water and 2 mg per adult per day in a fluoridated area.

Sources of fluoride in ground water: Fluoride problem may be endemic *i.e.,* restricted to the areas with high fluoride levels. However, the problem is prevalent in various geographical areas of the world. The occurrence of high levels are observed in the areas with:

(*i*) Sediments of marine origin in mountainous areas *e.g.,* Syria, Turkey, Mediterranean regions, Iraq, Iran etc.

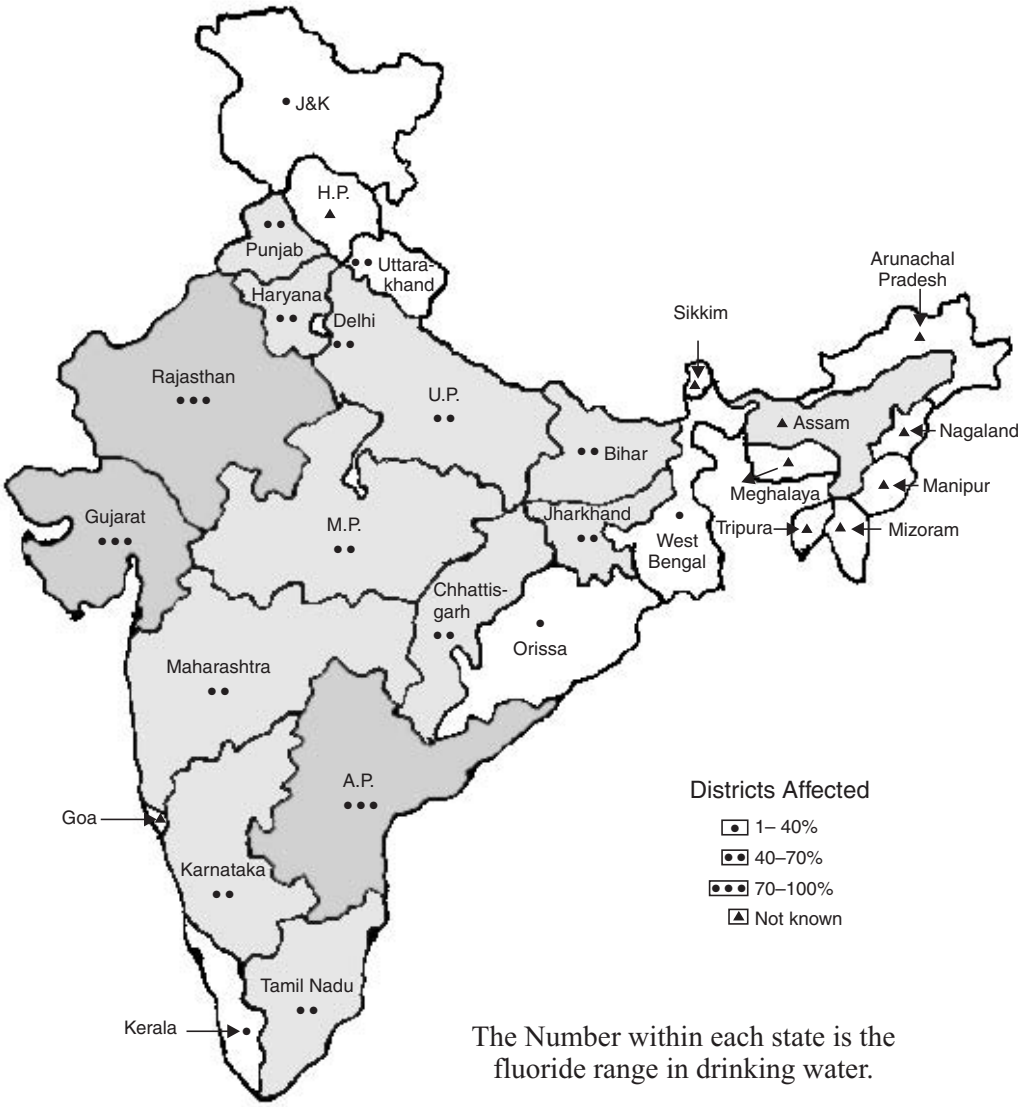
(*ii*) Volcanic rocks-Jordan, Sudan, Uganda, Kenya, Ethiopia, Nairobi, Tanzania, etc. Soda lakes have high fluoride concentration *i.e.*, upto 2800 mg/L.

(*iii*) Igneous and metamorphic rocks. *e.g.,* Granitic and gneissic rocks. *e.g.*, India, Pakistan, China, Thailand, Sri Lanka, southern Africa, west Africa.

Fluoride in ground water comes due to dissolution of fluorite, apatite and topaz from local bedrock. Presence of calcium limits fluoride concentration in water. High concentration of fluoride has been observed in aquifers poor in calcium and rich in fluoride bearing minerals.

Problem of fluorosis in India: In India fluorosis is a serious national problem. The seriously affected areas are villages in Andhra Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Tamil Nadu and Gujarat.

The highest concentration, to date, has been reported from Rewari district of Haryana *i.e.,* 48 mg/L. An estimated 62 million people including 6 million children in India are affected by various types of fluorosis.



Source: UNICEF State of Art Report, 1999

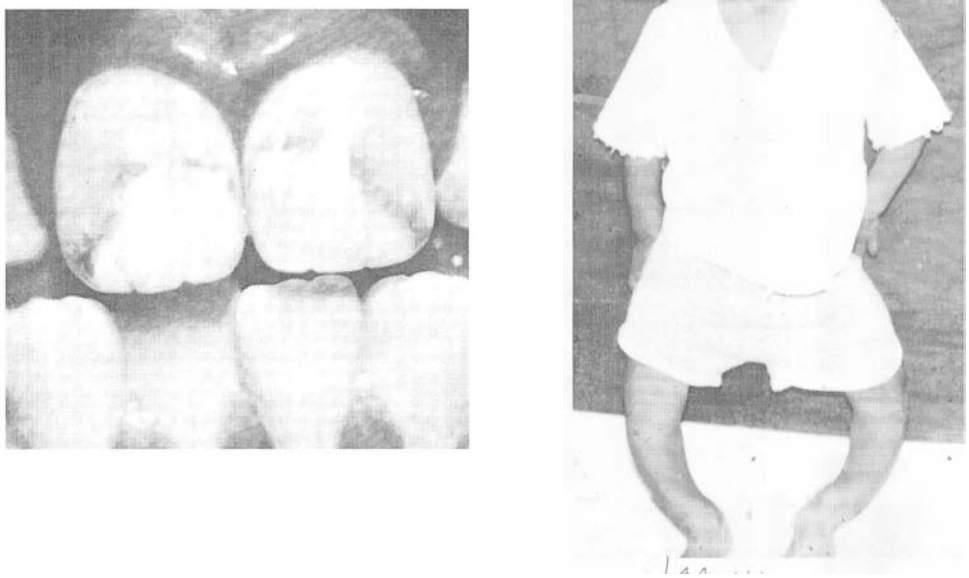
Fig. 4.3. Fluorosis prevalent states of India.

Although it is difficult to assess exact extent of affected people as the monitoring of ground water of wells and handpumps is not uniform *i.e.,* all villages of the district are not monitored or samples are taken from some handpumps in a particular locality ignoring others. As per WHO estimates about 10 to 25% of rural population of various states is at risk.

Health problems due to fluorosis: Fluoride expose may lead to dental (enamel) fluorosis and skeletal fluorosis (Fig. 4.4). Severity of fluorosis depends on fluoride exposure and period of development during exposure. Dental fluorosis may vary from mild discoloration of tooth surface to severe yellow or brown striations or mottling, loss of enamel and dental cavities. In the U.S. prevalence of severe enamel

fluorosis is very low below 2 mg/L of fluoride in drinking water. High fluoride exposure in terms of high levels in drinking water and high duration of exposure may lead to crippling skeletal fluorosis characterised by osteosclerosis, calcification of ligaments and tendons and extreme bone deformities.

Carcinogenicity of fluoride in the tests on experimental animals could not be established. No effects have been observed on reproduction, reproductive organs or foetus development.



(*a*) (*b*)

Fig. 4.4. Dental fluorosis (*a*) and skeletal fluorosis (*b*).

Fluoride standards in drinking water: WHO has set the value of fluoride in drinking water at 1.5 mg/L. However, this guideline value of WHO is not a fixed one but is supposed to be adopted in consideration with the local conditions.

Fluoride removal from drinking water: Where alternative source of drinking water is not available, defluoridation of drinking water is the only remedy. It can be done with the help of bone charcoal. **Nalgonda process** developed and adopted by National Environmental Engineering Institute (NEERI) can be used at community and household level. The process uses aluminium sulfate to remove fluoride. The flocs of aluminium hydroxide formed in the process takes a few hours to settle which may be discarded.

4.5 MINERAL RESOURCES

Minerals are naturally occurring, inorganic, crystalline solids having a definite chemical composition and characteristic physical properties. There are thousands of minerals occurring in different parts of the world. However, most of the rocks, we see everyday are just composed of a few common minerals like quartz, feldspar, biotite, dolomite, calcite, laterite etc. These minerals, in turn, are composed of some elements like silicon, oxygen, iron, magnesium, calcium, aluminium etc.

Uses

Minerals find use in a large number of ways in everyday use in domestic, agricultural, industrial and commercial sectors and thus form a very important part of any nation's economy. The main uses of minerals are as follows:

(*i*) Development of industrial plants and machinery. *e.g.* iron, coal, aluminium, lead chromium, nickel, mercury, cadmium etc.

(*ii*) Generation of energy *e.g.* coal, lignite, uranium.

(*iii*) Construction, housing, settlements, *e.g.* iron, aluminium, silicate, limestone.

(*iv*) Defence equipments (weapons, armaments) *e.g.* copper, chromium, cobalt, manganese, iron, lead.

(*v*) Transportation means *e.g.* iron, lead, aluminium, platinum.

(*vi*) Communication (telephone wires, cables, electronic devices) *e.g.* copper, lead, nickel.

(*vii*) Medicinal system (particularly in Ayurvedic system) *e.g.* gold, silver, iron.

(*viii*) Formation of alloys for various purposes *e.g.* steel alloys.

(*ix*) Agriculture (as fertilizers, seed dressings and fungicides) *e.g.* zineb containing zinc, maneb containing manganese etc.

(*x*) Jewellery *e.g.* gold, silver, platinum, diamond.

Based on their properties, minerals are basically of two types:

(*i*) Non-metallic minerals *e.g.* graphite, diamond, quartz, feldspar.

(*ii*) Metallic minerals *e.g.* bauxite, laterite, haematite etc.

Use of metals by human beings has been so extensive since the very beginning of human civilization that two of the major epochs of human history are named after them as Bronze Age and Iron Age. The reserves of metals and the technical know-how to extract them have been the key elements in determining the economy and political power of nations. Out of the various metals, those used in maximum quantity are iron and steel (740 million metric tons annually) followed by manganese, copper, chromium, aluminium and nickel.

Distribution and uses of some of the major metallic and non-metallic minerals are given in Tables 4.2 and 4.3.

Table 4.2. Major Reserves and Important Uses of Some of the Major Metals

Metal	*Major world reserves*	*Major uses*
Aluminium	Australia, Guinea, Jamaica	Packaging food items, transportation, utensils, electronics
Chromium	CIS, South Africa	For making high strength steel alloys, in textile/tanning industries
Copper	U.S.A., Canada, CIS, Chile, Zambia	Electric and electronic goods, building, construction, vessels
Iron	CIS, South America, Canada, U.S.A.	Heavy machinery, steel production transportation means
Lead	North America, U.S.A., CIS	Leaded gasoline, Car batteries, paints, ammunition
Manganese	South Africa, CIS, Brazil, Gabon	For making high strength, heat-resistant steel alloys
Platinum group	South Africa, CIS	Use in automobiles, catalytic converters, electronics, medical uses.
Gold	South Africa, CIS, Canada	Ornaments, medical use, electronic use, use in aerospace
Silver	Canada, South Africa, Mexico	Photography, electronics, jewellery
Nickel	CIS, Canada, New Caledonia	Electroplating

Table 4.3. Major Uses of Some Non-metallic Minerals

Non-metal mineral	*Major uses*
Silicate minerals	Sand and gravel for construction, bricks, paving etc.
Limestone	Used for concrete, building stone, used in agriculture for neutralizing acid soils, used in cement industry
Gypsum	Used in plaster wall-board, in agriculture
Potash, phosphorite	Used as fertilizers
Sulphur pyrites	Used in medicine, car battery, industry.

It is evident from the Tables that the CIS countries (The Commonwealth of Independent States *i.e.* 12 republics of former USSR), the United States of America, Canada, South Africa and Australia are having the major world reserves of most of the metallic minerals. Due to huge mineral and energy resources, the USA became the richest and the most powerful nation in the world in even less than 200 years. Japan too needs a mention here, as there are virtually no metal reserves, coal, oil and timber resources in Japan and it is totally dependent on other countries for its resources. But, it has developed energy efficient technologies to upgrade these resources to high quality finished products to sustain its economy.

Minerals are sometimes classified as **Critical** and **Strategic**.

Critical minerals are essential for the economy of a nation *e.g.* iron, aluminium, copper, gold etc.

Strategic minerals are those required for the defence of a country *e.g.* Manganese, cobalt, platinum, chromium etc.

Some Major Minerals of India

(*a*) **Energy generating minerals**

Coal and lignite: West Bengal, Jharkhand, Orissa, Madhya Pradesh, Andhra Pradesh.

Uranium (Pitchblende or Uranite ore): Jharkhand, Andhra Pradesh (Nellore, Nalgonda), Meghalaya, Rajasthan (Ajmer).

(*b*) **Other commercially used minerals**

Aluminium *(Bauxite ore):* Jharkhand, West Bengal, Maharashtra, Madhya Pradesh, Tamil Nadu.

Iron *(Haematite and magnetite ore):* Jharkhand, Orissa, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Goa.

Copper *(Copper pyrites):* Rajasthan (Khetri), Bihar, Jharkhand, Karnataka, Madhya Pradesh, West Bengal, Andhra Pradesh and Uttarakhand.

4.6 FOREST WEALTH

Forests are one of the most important natural resources on this earth. Covering the earth like a green blanket these forests not only produce innumerable material goods, but also provide several environmental services which are essential for life.

Forests are of immense value to us. They are not only useful for industry but also for rural economic growth. They offer huge potential for reducing poverty while also conserving their valuable key resources.

Figure 4.5 compares the value of forests in terms of economic products and environmental services.

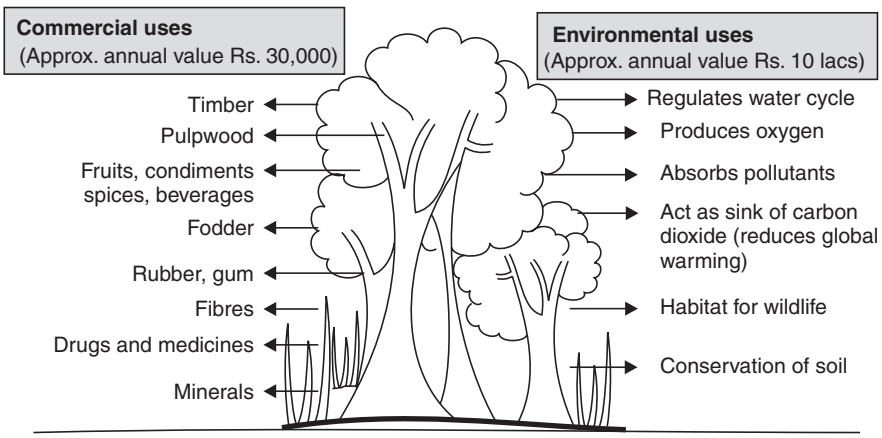


Fig. 4.5. Economic vs. Environmental value of forests.

Economic uses: Forests provide us a large number of commercial goods which include timber, firewood, pulpwood, food items, gum, resins, non-edible oils, rubber, fibres, lac, bamboo canes, fodder, medicine, drugs and many more items.

Half of the timber cut each year is used as fuel for heating and cooking. One third of the wood harvest is used for building materials as lumber, plywood and hardwood, particle board and chipboard. One sixth of the wood harvest is converted into pulp and used in paper industry. Many forest lands are used for mining, agriculture, grazing, and recreation and for development of dams.

Ecological uses: The ecological services provided by our forests may be summed up as follows:

- **Production of oxygen:** The trees produce oxygen by photosynthesis which is vital for life on this earth. They are rightly called as earth's lungs.
- **Reducing global warming:** The main greenhouse gas carbon dioxide (CO_2) is absorbed by the forests as a raw material for photosynthesis. Thus forest canopy acts as a sink for CO_2 thereby reducing the problem of global warming caused by greenhouse gas CO_2.
- **Wildlife habitat:** Forests are the homes of millions of wild animals and plants. About 7 million species are found in the tropical forests alone.
- **Regulation of hydrological cycle:** Forested watersheds act like giant sponges, absorbing the rainfall, slowing down the runoff and slowly releasing the water for recharge of springs. About 50–80 % of the moisture in the air above tropical forests comes from their transpiration which helps in bringing rains.
- **Soil conservation:** Forests bind the soil particles tightly in their roots and prevent soil erosion. They also act as wind-breaks.
- **Pollution moderators:** Forests can absorb many toxic gases and can help in keeping the air pure. They have also been reported to absorb noise and thus help in preventing air and noise pollution.

While a typical tree produces annually commercial goods worth about Rs. 30,000 it provides environmental services worth nearly Rs. one lakh.

4.7 MATERIAL CYCLES

Various materials including different nutrients and metals move in the ecosystem in a cyclic manner. The major reserves or storage compartment of the materials are known as reservoirs.

When the major reservoir of a nutrient is in the atmosphere, it is known as a **gaseous cycle.** *e.g.,* nitrogen cycle, which has its reservoir in the form of nitrogen gas (N_2) constituting about 78% of the atmosphere. When the reservoir is in the earth's crust or sediments, it is known as a **sedimentary cycle** *e.g.,* phosphorus cycle–which has its reserve as phosphate rocks. Sulphur cycle is an example of an intermediate type, which has reservoir both in soil and the atmosphere.

The amount of material and its rate of movement in a cycle is referred to as **flux**, generally expressed as g/yr or a similar expression. Movement of the materials from one reservoir to another may be driven by physical agents like wind or gravitational energy. It may also be due to chemical energy, *e.g.,* when the water body reaches saturation–the reservoir is chemically full and therefore, no longer can hold it as such. Then the material usually is precipitated out.

The average time for which a material (molecule of a substance) remains in a reservoir is known as its **residence time.** *e.g.,* residence time of heavy metals like mercury and lead is quite long in animal bodies but the residence time of lead (Pb) in the atmosphere is quite short. (about four days).

Nutrients like carbon, nitrogen, sulphur, oxygen, hydrogen, phosphorus etc. move in circular paths through biotic and abiotic components and are known as **biogeochemical cycles.** Water also moves in a cycle, known as hydrological cycle. The nutrients too move through the food chain and ultimately reach the detritus compartment (containing dead organic matter) where various micro-organisms carry out decomposition. Various organically bound nutrients of dead plants and animals are converted into inorganic substances by microbial decomposition that are readily used up by plants (primary producers) and the cycle starts afresh.

4.7.1 Carbon Cycle

Sometimes human interferences disturb the normal cycling of nutrients and create ecosystem imbalance. For example, nature has a very balanced carbon cycle (Fig. 4.6). Carbon, in the form of carbon dioxide is taken up by green plants as a raw material for photosynthesis, through which a variety of carbohydrates and other organic substances are produced. It moves through the food chain and ultimately organic carbon present in the dead matter is returned to the atmosphere as carbon dioxide by microorganisms. Respiration by all organisms produces carbon dioxide, while the latter is used up by plants.

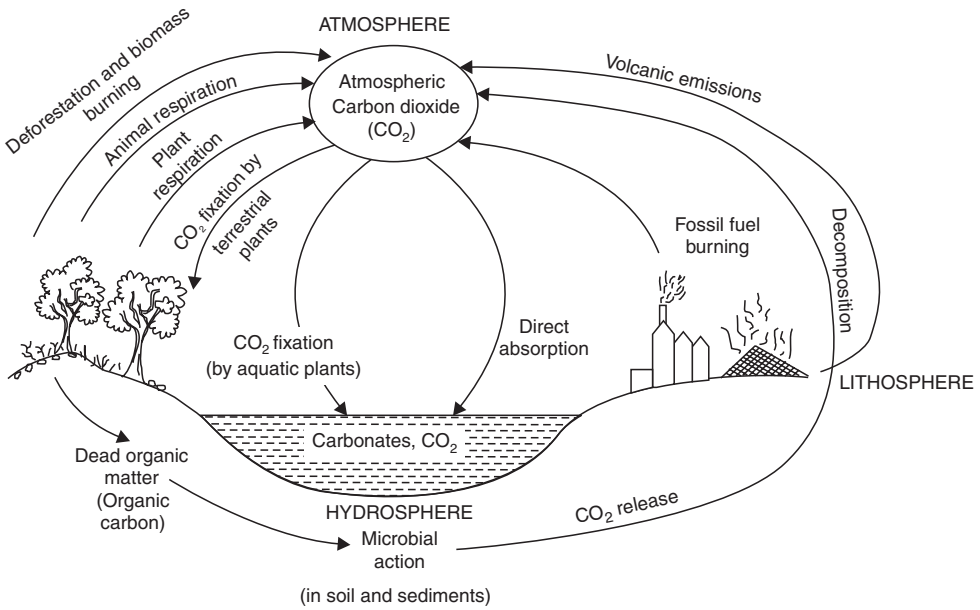


Fig. 4.6. Carbon cycle, showing both natural and man-made fluxes.

Carbon plays a crucial role in regulation of global climate. Human activities have caused carbon fluxes to increase by releasing carbon as carbondioxide from reservoirs through burning of fossil fuels and plant biomass. Deforestation also plays an important role as the sink of CO_2 is lost due to loss of tree canopy. The forest canopies (leaf cover) can otherwise act as excellent CO_2 sinks by using the atmospheric CO_2 for photosynthesis. Thus, there has been an increase in the atmospheric carbon over the past two hundred years, that is resulting in global warming problem.

4.7.2 Nitrogen Cycle

Nitrogen is present in the atmosphere as N_2 in large amount (78%) and it is fixed either by the physical process of lightening or biologically by some bacteria and/or cyanobacteria (blue green algae). The nitrogen is taken up by plants and used in metabolism for biosynthesis of amino acids, proteins, vitamins etc. and passes through the food chain. After death of the plants and animals, the organic nitrogen in dead tissues is decomposed by several groups of ammonifying bacteria converting organic -N into ammonia and nitrifying bacteria like *Nitrosomonas* and *Nitrobacter* which convert them into nitrites and nitrates respectively, which are again used by plants. Some bacteria like *Pseudomonas* convert nitrates, into molecular nitrogen or N_2 by **denitrification** which is released back into the atmosphere and the cycle goes on.

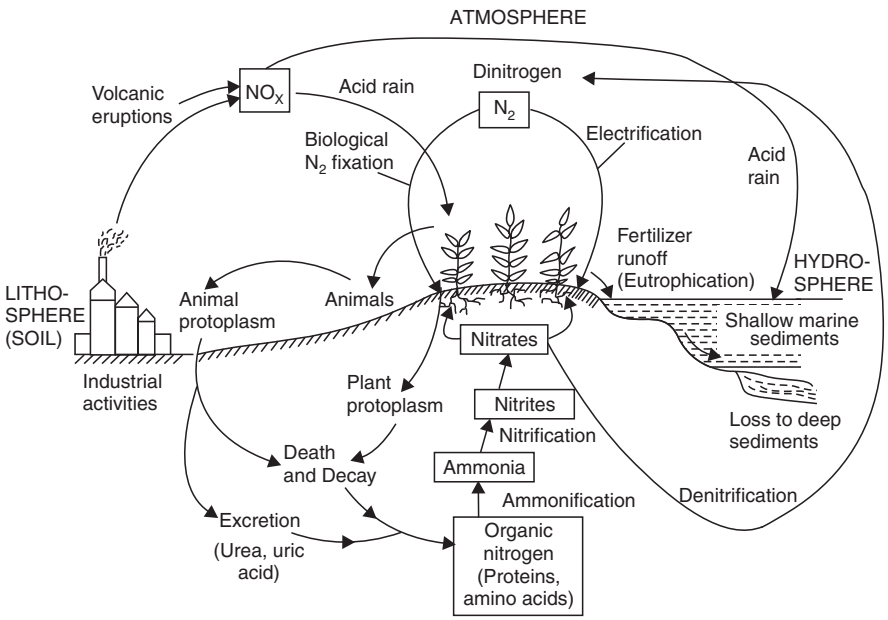


Fig. 4.7. Nitrogen cycle—a gaseous cycle with major reserve as N_2 (78%) in the atmosphere. Circulation of N- between living components and soil/atmosphere is mediated by a group of micro-organisms which convert one form of N into another.

4.7.3 Sulphur Cycle

Sulphur has its reservoir both in atmosphere (as oxides of sulphur, hydrogen sulphide) and in rocks and sediments (as mineral pyrites). Atmospheric sulphur plays an important role, as the oxides of sulphur

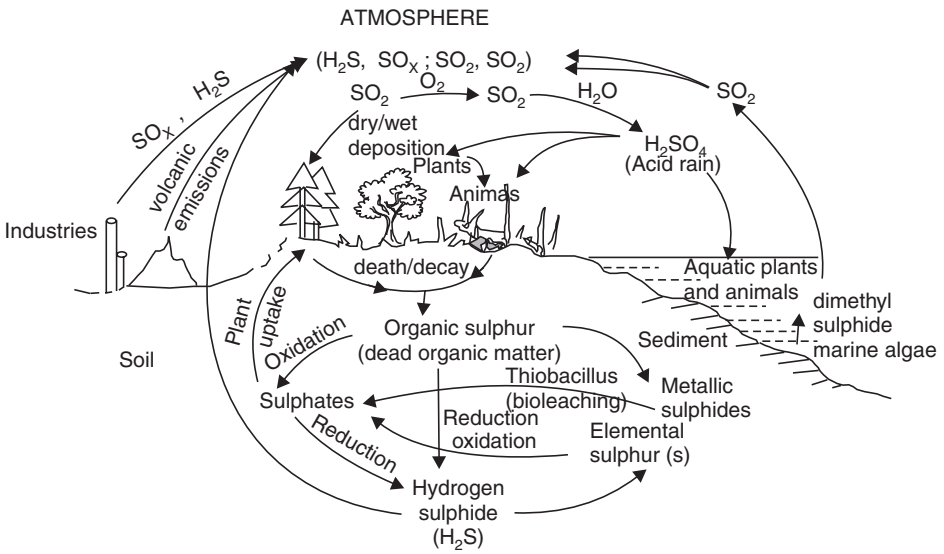


Fig. 4.8. Sulphur cycle—an intermediate type cycle with reservoir of S both in atmosphere and sediments. In the sediments transformations take place from one form to another through microbe mediated oxidation—reduction reactions. Human activities have altered the fluxes of S-cycle mainly by fossil fuel burning.

react with rain water producing sulphuric acid, which comes down as 'acid rain'. Oxides of sulphur (SO_x) are released into the atmosphere due to burning of fossil fuels. Thus human beings play a significant role in the material cycling of sulphur. In the soil or water, there are different groups of micro-organisms which carry out oxidation and reduction of various sulphur compounds. A special role is played by **Thiobacillus** bacterium, which converts sulphides into sulphuric acid. These bacteria help in bio-leaching of metals from ores containing pyrites (S) as impurities. Figure 4.8 illustrates the complex sulphur cycle.

I. QUESTIONS

1. Discuss the importance and availability of water on the earth.
2. What is an aquifer? Discuss its types.
3. Discuss hydrological cycle and its importance.
4. What are water borne diseases? Name a few of them.
5. What are the sources of fluoride in ground water?
6. What are the uses of various types of minerals?
7. Discuss the major environmental impacts of mineral extraction.
8. Discuss major uses of forests. How would you justify that ecological uses of forests surpass commercial uses?
9. What are major causes and consequences of deforestation?
10. Describe carbon cycle. How does carbon in the environment play a role in regulating global climate?

II. OBJECTIVE TYPE QUESTIONS

(A) FILL IN THE BLANKS

1. About ..... % of the earth's surface is covered by water.
2. Only ..... % of total water on earth is readily available to us in the form of groundwater and fresh water.
3. A layer of sediment or rock that is highly permeable and contains water (ground water) is called an ..... .
4. Aquifers which are overlaid by permeable earth material and are recharged by seeping water are called ..... aquifers.
5. Aquifers which are sandwiched between two impermeable layers of rocks or sediments are called ..... aquifers.
6. Shallow depressions filled with water forms ..... and ..... .
7. Examples of wetlands are ..... and ..... .
8. Typhoid is called by a ..... .
9. Concentration of fluoride should not exceeds ..... mg/L in drinking water.

10. Uranium mining is done in ..... in A.P.
11. ..... can be extracted from bauxite ore.
12. Deforestation means ..... of trees.
13. Forests can absorb ..... gases.
14. Oxides of sulphur react with atmospheric moisture/rain water to form ..... acid.
15. ..... bacteria convert organic-N into ammonia.

(B) CHOOSE THE CORRECT ANSWER

1. During photosynthesis trees produce
(*a*) Oxygen (*b*) Carbon dioxide
(*c*) Nitrogen (*d*) Carbon monoxide.

2. Forests prevent soil erosion by binding soil particles in their
(*a*) Stems (*b*) Leaves
(*c*) Roots (*d*) Buds

3. Cholera is called by
(*a*) Bacterium (*b*) insect
(*c*) Fungus (*d*) Snail

4. Forests produce
(*a*) oxygen (*b*) medicines
(*c*) Timber (*d*) all of these.

5. Water borne disease is
(*a*) cholera (*b*) dysentery
(*c*) typhoid (*d*) all of these.

(C) WRITE TRUE OR FALSE

1. Surface water is more in quantity than the ground water. (True/False)
2. Mining of uranium exposes local people to radiation hazard. (True/False)
3. Soil erosion helps to maintain fertility. (True/False)
4. Optimal level of fluoride is require in drinking water. (True/False)
5. Forests are sinks for CO_2. (True/False)

5

Energy

5.1 INTRODUCTION

Energy is the capacity to do work, produce motion or force or carry out transformations. It can be in different forms like thermal energy, electrical energy, mechanical energy or chemical energy. The raw form in which the energy resources occur in nature are the **primary energy resources** (coal, petroleum, natural gas, wind, solar) which are converted into some intermediate form (steam or chemicals) that are finally converted into usable or **secondary energy** (fuels, electricity etc.). Every development activity depends on energy. Therefore, energy resources and their usage directly influence national economy and growth of civilisation. While energy requirements of primitive man were limited, the energy needs in modern times have tremendously increased due to fast development, increasing transportation, industrialisation, raised standards of living and rapid population growth.

Energy consumption of a nation is usually considered as an index of its development. This is because almost all the developmental activities are directly or indirectly dependent upon energy. We find wide disparities in per capita energy use between the developed and the developing nations.

The first form of energy technology probably was the fire, which produced heat and the early man used it for cooking and heating purposes. Wind and hydropower have also been in use for the last 10,000 years. The invention of steam engines replaced the burning of wood by coal and coal was later replaced to a great extent by oil. In 1970's due to Iranian revolution and Arab oil embargo the prices of oil shot up. This ultimately led to exploration and use of several alternate sources of energy.

5.2 TYPES OF ENERGY RESOURCES

All energy resources are available in nature in their raw form, which are explored, extracted, processed and converted into final usable forms.

Based upon their usage over a long time, energy resources are generally classified as conventional and non-conventional. Demarcation between the two is not so rigid, because what is a non-conventional form today, may in due course of time, become conventional.

- **Conventional Energy Resources:** Energy resources that are traditionally in use for all these years (particularly prior to the oil crisis of 1973) are known as conventional forms, *e.g.* coal, petroleum, natural gas, fire-wood, hydropower and even nuclear fission fuels.
- **Non-conventional Energy Resources:** These include the alternate resources of energy that are being considered and commercialised for large scale use after the oil crisis. These resources are going to have increased share of energy use in future. These alternate resources are generally renewable forms including solar, wind, geothermal, ocean wave, tidal, biomass, biogas, nuclear fusion energy etc.

  A more appropriate categorisation of an energy resource is based on its durability and regenerating capacity, which classifies it as renewable or non-renewable.
- **Renewable Resources are those which can be generated continuously in nature and are inexhaustible** *e.g.* wood, solar energy, wind energy, tidal energy, hydropower, biomass energy, bio-fuels, geo-thermal energy and hydrogen. They are also known as non-conventional sources of energy and they can be used again and again in an endless manner.
- **Non-renewable Resources which have accumulated in nature over a long span of time and cannot be quickly replenished when exhausted** *e.g.* coal, petroleum, natural gas and nuclear fuels like uranium and thorium.

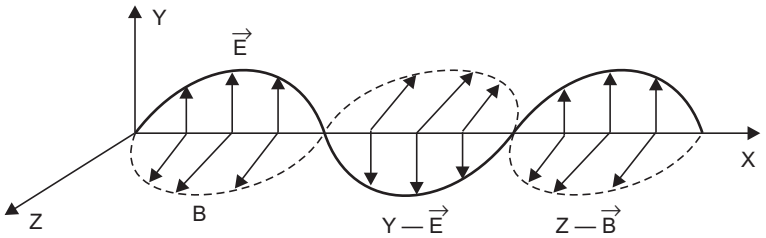
Wood is a renewable resource as we can get new wood by growing a sapling into a tree within 15–20 years but it has taken millions of years for the formation of coal from trees and cannot be regenerated in our life time, hence coal is not renewable.

5.3 ELECTROMAGNETIC RADIATIONS

Life on earth has evolved in an environment that has several types of electromagnetic radiations coming from sources like thunderstorms, lightening, solar radiations, etc. Human beings have also added electromagnetic radiations in several ways through high frequency electromagnetic radiations (EMR) such as microwaves, X-rays, electric power systems and distribution systems, transportation, electric gadgets, mobile phones, sound systems and so on. The electromagnetic radiations have increased more than a million times in the environment due to human activities as compared to natural electromagnetic radiations.

Properties of Electromagnetic Radiations

- Electromagnetic radiation (waves) can travel in space without any material medium.
- There is sinusoidal variation in electric field and similar in magnetic field, at right angles to each other.
- Both electric field $(\vec{E})$ and magnetic field $(\vec{B})$ vary with time and space and have the same frequency, as shown in Fig. 5.1.



X-direction of propagation of electromagnetic wave.

Fig. 5.1. Electromagnetic field.

- Both electric and magnetic field components coexist in time and space.
- Examples of electromagnetic radiation are radiowaves infrared rays, X-rays, γ-rays, microwaves.
- Electromagnetic radiations have a wide range of wavelength. Table 5.1 shows the wavelength and sources of various types of these waves.

Table 5.1. Range of Different Electromagnetic Radiations

Type	*Wavelength (m)*	*Source*
Radiowaves	0.3 to 6×10^{2}	Oscillating circuit
Microwaves	10^{-3} to 0.3	Oscillating current in special vacuum tube
Infra-red	8×10^{-7} to 1×10^{-3}	Excitation of atoms and molecules
Visible light	4×10^{-7} to 8×10^{-7}	Excitation of valency electrons.
Ultra violet	6×10^{-10} to 4×10^{-7}	Excitation of atom, spark and arc lamp
X-rays	1×10^{-13} to 3×10^{-8}	Sudden deceleration of high energy electrons.
Gamma rays	6×10^{-14} to 1×10^{-10}	Nuclear origin

Different electromagnetic radiations are of different use. While the visible range light is responsible for photosynthesis by green plants, which forms the primary productivity—the base of the food chain. Other types of radiations find use in various sectors of transportation, communication, medical and scientific research.

Exposure of living organisms including human beings to some of these electromagnetic radiations has become a cause of alarm, as these waves have been reported to have several harmful effects on health, including increased chances of tumor formation, adverse reproductive effects and behavioral and neurological disorders.

5.4 CONVENTIONAL ENERGY RESOURCES (FOSSIL FUEL BASED)

These are the fossil fuels like coal, petroleum, natural gas and nuclear fuels. These were formed by the decomposition of the remains of plants and animals buried under the earth millions of years ago. These fuels are very precious because they have taken a long time to be formed and if we exhaust their

reserves at such a fast rate as we have been doing, ever since we discovered them, then very soon we will lose these resources forever.

5.4.1 Coal

Coal was formed 255–350 million years ago in the hot, damp regions of the earth during the carboniferous age. The ancient plants along the banks of rivers and swamps were buried after death into the soil and due to the heat and pressure gradually got converted into peat and coal over millions of years. There are mainly three types of coal, namely ***anthracite*** (hard coal), ***bituminous*** (soft coal) and ***lignite*** (brown coal). Anthracite coal has maximum carbon (90%) and calorific value (8700 kcal/kg.). Bituminous, lignite and peat contain 80, 70 and 60% carbon, respectively. Coal is the most abundant fossil fuel in the world. ***At the present rate of usage, the coal reserves are likely to last for about 200 years and if its use increases by 2% per year, then it will last for another 65 years.***

India has about 5% of world's coal and Indian coal is not very good in terms of heat capacity. Major coal fields in India are Raniganj, Jharia, Bokaro, Singrauli and Godavari valley. The coal states of India are Jharkhand, Orissa, West Bengal, Madhya Pradesh, Andhra Pradesh and Maharashtra. Anthracite coal occurs only in J & K.

When coal is burnt it produces carbon dioxide, which is a greenhouse gas responsible for causing enhanced global warming. Coal also contains impurities like sulphur and as it burns the smoke contains toxic gases like oxides of sulphur and nitrogen. Coal conversion technologies involve conversion of coal from solid form to liquid or gaseous form by *coal liquefaction* and *gasification*, respectively. Direct burning of coal releases emissions like smoke, particulate matter, SO_X, NO_X, CO and CO_2, whereas gaseous or liquid fuel forms cause less pollution. Energy from petroleum is harnessed by refining and fractional distillation.

5.4.2 Petroleum

It is the lifeline of global economy. There are 13 countries in the world having 67% of the petroleum reserves which together form the OPEC (Organization of Petroleum Exporting Countries). About 1/4th of the oil reserves are in Saudi Arabia.

At the present rate of usage, the world's crude oil reserves are estimated to get exhausted in just 40 years. Some optimists, however, believe that there are some yet undiscovered reserves. Even then the crude oil reserves will last for another 40 years or so. Crude petroleum is a complex mixture of alkane hydrocarbons. Hence, it has to be purified and refined by the process of **fractional distillation,** during which process different constituents separate out at different temperatures. We get a large variety of products from this, namely, petroleum gas, kerosene, petrol, diesel, fuel oil, lubricating oil, paraffin wax, asphalt, plastic etc.

Basic steps in harnessing energy from petroleum include exploration of oil resources, drilling of wells, production, storage and transport of crude oil, refining of crude oil, storage and transportation of products.

Exploration is usually done in areas having sedimentary rocks, where petroleum deposits generally occur, which may be on-shore (land) or off-shore (sea) at shallow, medium or large depths.

Drilling is done from specifically formed drilling platforms. For enhanced extraction, the following techniques are used:

- By injecting fluid (air, gas, steam, water) into the well.
- By using chemical explosives to loosen tight formations.
- By adding chemicals to reduce viscosity of the crude oil.
- By allowing microbial growth inside to increase bulk, reduce viscosity and enhance recovery, known as Microbially Enhanced Oil Recovery (MEOR).
- By controlled underground burning to push up oil.

After extraction, crude oil is separated from natural gas and water, stored and transported through pipelines or tankers.

Crude oil is refined by the following processes:

- Separation of some components by distillation.
- Chemical purification or removal of impurities by adsorption (on charcoal).
- Formation of hydrocarbons by cracking or hydrogenation.

During refining of crude oil, several products are obtained that are used in domestic, transport, industrial and electric power sectors.

Petroleum is a cleaner fuel as compared to coal as it burns completely and leaves no residue. It is also easier to transport and use. That is the reason why petroleum is preferred amongst all the fossil fuels.

Liquefied Petroleum Gas (LPG): The main component of petroleum is butane, the other being propane and ethane. The petroleum gas is easily converted to liquid form under pressure as LPG. It is odourless, but the LPG in our domestic gas cylinders gives a foul smell. This is, in fact, due to ethyl mercaptan, a foul smelling gas, added to LPG so that any leakage of LPG from the cylinder can be detected instantaneously.

Oil fields in India are located at Digboi (Assam), Gujarat Plains and Bombay High, offshore areas in deltaic coasts of Godavari, Krishna, Kaveri and Mahanadi.

5.4.3 Natural Gas

It is mainly composed of methane (95%) with small amounts of propane and ethane. It is a fossil fuel. Natural gas deposits mostly accompany oil deposits because it has been formed by decomposing remains of dead animals and plants buried under the earth. **Natural gas is the cleanest fossil fuel.** It can be easily transported through pipelines. It has a high calorific value of about 50 kJ/g and burns without any smoke.

Currently, the amount of natural gas deposits in the world are of the order of 80,450g m^{-3}. Russia has maximum reserves (40%), followed by Iran (14%) and USA (7%). Natural gas reserves are found in association with all the oil fields in India. Some new gas fields have been found in Tripura, Jaisalmer, off-shore area of Mumbai and the Krishna-Godavari Delta.

Natural gas is used as a domestic and industrial fuel. It is used as a fuel in thermal power plants for generating electricity. It is used as a source of hydrogen gas in fertilizer industry and as a source of carbon in tyre industry.

- **Compressed Natural Gas (CNG):** It is being used as an alternative to petrol and diesel for transport of vehicles. Delhi has totally switched over to CNG where buses and auto-rickshaws run on this new fuel. CNG use has greatly reduced vehicular pollution in the city.
- **Synthetic Natural Gas (SNG):** It is a mixture of carbon monoxide and hydrogen. It is a connecting link between a fossil fuel and substituted natural gas. Low grade coal is initially transformed into synthetic gas by gasification followed by catalytic conversion to methane.

5.4.4 Nuclear Energy

Nuclear energy is known for its high destructive power as evidenced from nuclear weapons. The nuclear energy can also be harnessed for providing commercial energy. Nuclear energy can be generated by two types of reactions:

(*i*) *Nuclear fission*: It is the nuclear change in which nucleus of certain isotopes with large mass numbers are split into lighter nuclei on bombardment by neutrons and a large amount of energy is released through a chain reaction as shown in Fig. 5.2

$$_{92}U^{235} + {}_{0}n^{1} \longrightarrow {}_{36}Kr^{92} + {}_{56}Ba^{141} + 3\ {}_{0}n^{1} + \text{Energy}$$

Nuclear reactors make use of nuclear chain reaction. In order to control the rate of fission, only 1 neutron released is allowed to strike for splitting another nucleus. Uranium-235 nuclei are most commonly used in nuclear reactors.

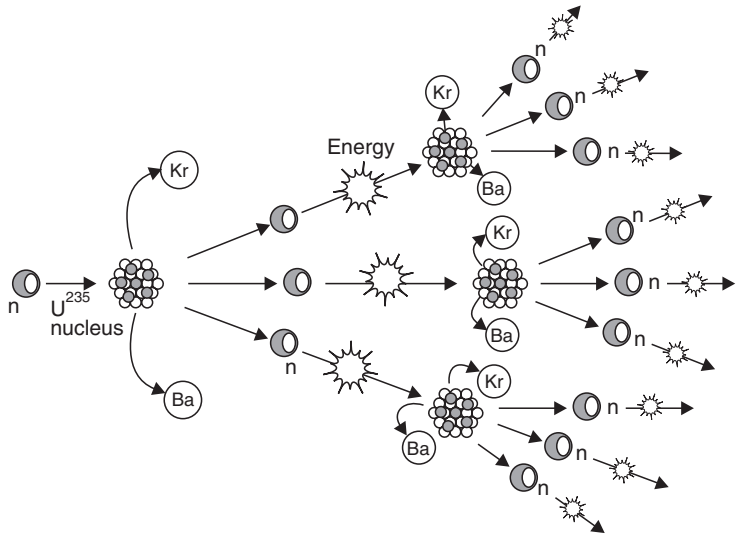


Fig. 5.2. Nuclear fission—a chain reaction initiated by one neutron that bombards a Uranium (U^{235}) nucleus, releasing a huge quantity of energy, two smaller nuclei (Ba, Kr) and 3 neutrons.

(*ii*) *Nuclear fusion*: Here two isotopes of a light element are forced together at extremely high temperatures (1 billion ºC) until they fuse to form a heavier nucleus releasing enormous energy in the process. It is difficult to initiate the process but it releases more energy than nuclear fission (Fig. 5.3).

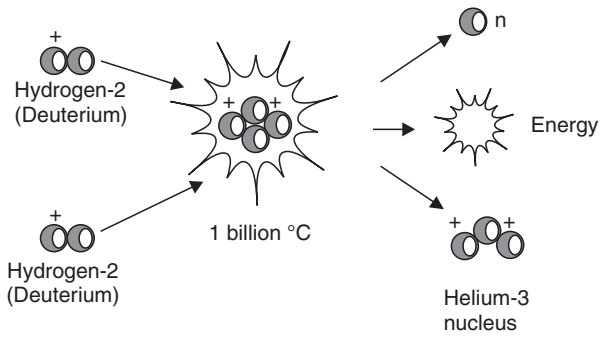


Fig. 5.3. Nuclear fusion reaction between two hydrogen-2 nuclei, which takes place at a very high temperature of 1 billion °C; one neutron and one fusion nucleus of helium-3 is formed along with a huge amount of energy.

$$_1H^2 + {}_1H^2 \longrightarrow {}_3He^2 + {}_0n^1 + \text{Energy}$$

Two hydrogen-2 (Deuterium) atoms may fuse to form the nucleus of Helium at 1 billion ºC and release a huge amount of energy. Nuclear fusion reaction can also take place between one Hydrogen-2 (Deuterium) and one Hydrogen-3 (Tritium) nucleus at 100 million ºC forming Helium-4 nucleus, one neutron and a huge amount of energy.

Nuclear energy has tremendous potential but any leakage from the reactor may cause devastating nuclear pollution e.g. the Chernobyl nuclear disaster (1986). Disposal of the nuclear waste is also a big problem.

Nuclear power in India is still not very well developed. The power plants in India are Pressurised Heavy Water Reactor (PHWR) Power plant type. The nuclear power plants are located at Tarapur (Maharashtra), Rana Pratap Sagar near Kota (Rajasthan), Kalpakkam (Tamil Nadu), Narora (U.P.), Kakrapar (Gujarat), Kaiga (Karnataka), Rawatbhata (Rajasthan) and Kudankulum (Tamil Nadu).

5.5 NON-CONVENTIONAL ENERGY SOURCES

5.5.1 Hydroelectric (Hydropower) Energy

The water flowing in a river is collected by constructing a big dam where the water is stored and allowed to fall from a height. Potential energy stored in water reservoir at high head is converted into kinetic energy in the flowing water. The blades of the turbine located at the bottom of the dam move with the fast moving water which in turn rotate the generator and produce electricity. We can also construct mini or micro hydelpower plants on the rivers in hilly regions for harnessing the hydro energy on a small scale, but the minimum height of the waterfalls should be 10 metres. **The hydropower**

potential of India is estimated to be about 4×10^{11} kW hours. Till now we have utilised only a little more than 11% of this potential.

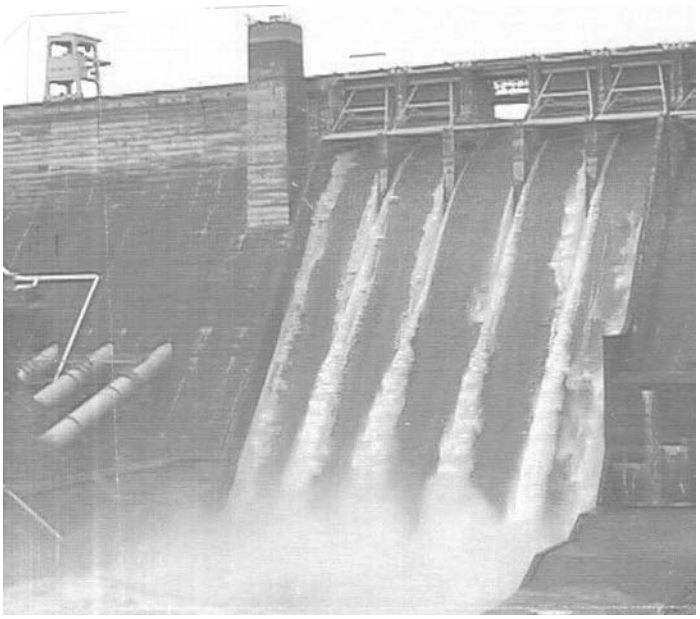


Fig. 5.4. Hydroelectric power (Dam).

Hydropower does not cause any pollution. It is renewable and normally the hydropower projects are multi-purpose projects that help in controlling floods, used for irrigation, navigation etc. However, big dams are often associated with a number of environmental impacts.

5.5.2 Solar Energy

Sun is the ultimate source of energy, directly or indirectly for all other forms of energy. The nuclear fusion reactions occurring inside the sun release enormous quantities of energy in the form of heat and light. The solar energy received by the near earth space is approximately 1.4 kilojoules/second/m^2 known as solar constant.

Traditionally, we have been using solar energy for drying clothes and food-grains, preservation of eatables and for obtaining salt from sea-water. Now we have several techniques for harnessing solar energy. Some important solar energy harvesting devices are discussed here.

(*i*) **Solar heat collectors:** These can be passive or active in nature. Passive solar heat collectors are natural materials like stones, bricks etc. or material like glass which absorb heat during the day time and release it slowly at night. Active solar collectors pump a heat absorbing medium (air or water) through a small collector which is normally placed on the top of the building.

(*ii*) **Photovoltaic cells (Solar cells) for direct conversion of solar radiations into electrical energy:** Solar cell or PV cell is made of thin wafers of semiconductor material like silicon that forms the semi-conducting N-P junction, corresponding to negative and positive electrodes. The N-and P-type materials are obtained by doping silicon with N-type and P-type impurities.

There are two types of **dopants** used in doping the tetravalent silicon:

- Pentavalents like arsenic (As), antimony (Sb) or phosphorus (P)
- Trivalents like Indium (In), Boron (B) or Aluminium (Al).

When we dope Si with a pentavalent element, four of its electrons bond with four silicon neighbours, whereas the fifth excess electron is free to move due to loose bonding. Here, the number of conduction electrons are more than the number of holes. Hence the majority charge carriers are negatively charged electrons and therefore known as **N-type semiconductors.**

On the other hand, when tetravalent silicon is doped with a trivalent element, the dopant has one outer electron less than Si. Therefore, this atom can form bonds on three sides with Si, but fails to form bond on one side. In order to hold the dopant atom (*e.g.* boron), tightly within the crystal lattice of Si, some of the electrons bond on outer side in the neighbouring area tend to slide into this vacant bond, leaving a 'hole' at its own site. This hole is available for conduction. Here the holes are the majority carriers while electrons are minority carriers.

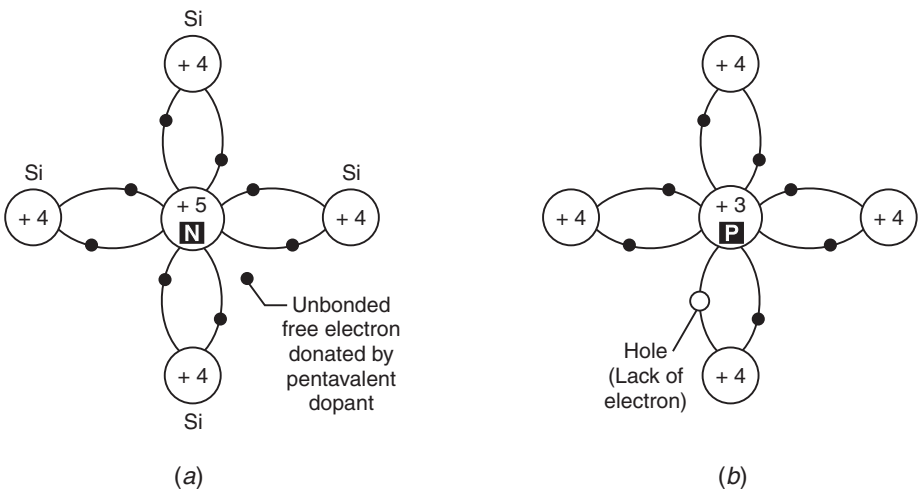


Fig. 5.5. (*a*) Pentavalent donor atom doped for N–type semiconductor (*b*) trivalent acceptor atom doped for P–type semiconductor.

As the solar radiations strike the thin transparent N-type layer, some of the radiations penetrate upto the thick P-type layer. Photons present in the light radiations result in liberation of electron-hole pairs in the P-N junction. Electrons (negative charge) are released from N-type semicouductor and holes (positive charge due to lack of electrons) are created in the **P-type semiconductor** (Fig. 5.5). The potential difference causes flow of electrons, when the electric circuit is completed by connecting electrodes to the load. Thus, there is direct conversion of solar energy to electrical energy.

Silicon used in PV cells can be obtained from silica or sand, which is abundantly available and inexpensive. The potential difference produced by a single PV cell of 4 cm^2 size is about 0.4–0.5 volts, produces a current of 60–75 milli amperes, and has a rated power of about 0.3 watts. Figure 5.6 shows the structure of a solar cell.

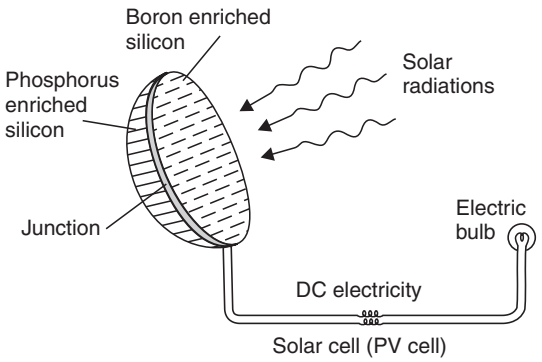


Fig. 5.6. Solar cell

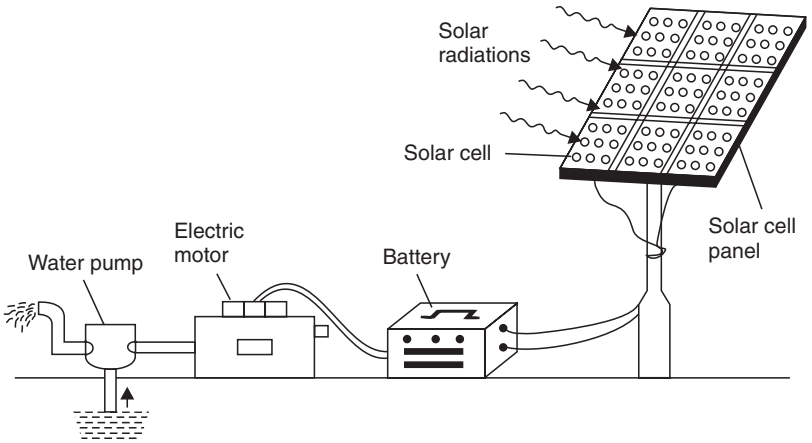


Fig. 5.7. A solar pump run by electricity produced by solar cells.

A group of solar cells joined together in a definite pattern form a solar panel which can harness a large amount of solar energy and can produce electricity enough to run street-light, irrigation water pump etc. (Fig. 5.7).

Solar cells are widely used in calculators, electronic watches, radios, street lighting, traffic signals, water pumps etc. They are also used in artificial satellites for electricity generation.

(*iii*) **Solar cooker:** Solar cookers make use of solar heat by reflecting the solar radiations using a mirror directly on to a glass sheet which covers the black insulated box within which the raw food is kept as shown in Fig. 5.8. A new design of solar cooker is now available which involves a spherical reflector (concave or parabolic reflector) instead of plane mirror that has more heating effect and hence greater efficiency.

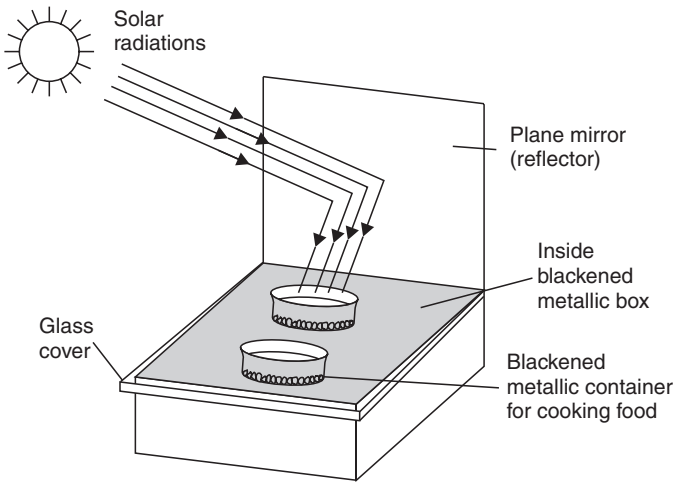


Fig. 5.8. Simple box-type solar cooker.

The food cooked in solar cookers is more nutritious due to slow heating. However, it has the limitation that it cannot be used at night or on cloudy days. Moreover, the direction of the cooker has to be adjusted according to the direction of the sun rays.

(*iv*) **Solar water heater:** It consists of an insulated box painted black from inside and having a glass lid to receive and store solar heat. Inside the box it has black painted copper coil through which cold water is made to flow in, which gets heated and flows out into a storage tank. The hot water from the storage tank fitted on roof top is then supplied through pipes into buildings like hotels and hospitals.

(*v*) **Solar furnace:** Here thousands of small plane mirrors are arranged in concave reflectors, all of which collect the solar heat and produce as high a temperature as 3000°C.

(*vi*) **Solar power plant:** Solar energy is harnessed on a large scale by using concave reflectors which cause boiling of water to produce steam. The steam turbine drives a generator to produce electricity.

5.5.3 Biomass Conversion Processes

Energy locked in biomass can be converted into useful energy by following methods:

(*i*) **Incineration or direct combustion:** The organic matter like dry municipal waste, bagasse, farm waste, wood chips etc., are burnt at high temperature in incinerators to produce heat, steam and electricity simultaneously, and hence it is called cogeneration.

(*ii*) **Thermochemical conversion:** The organic matter is decomposed through thermochemical processes having different temperature and pressure combinations.

Biomass can be converted into gases, through a process called **gasification,** by heating with limited air or heating at high temperature and pressure in the presence of steam and oxygen. Biomass can also be converted into gases, liquids or solids through **pyrolysis** at high temperature (500 – 900ºC) in the absence of oxygen. A large variety of products can be obtained from biomass through pyrolytic destructive distillation.

(*iii*) **Biochemical conversion:** It may involve anaerobic digestion or fermentation of biomass using microbes to yield biogas and alcohols.

5.5.4 Biogas Production

Biogas plants used in our country are basically of two types:

1. Floating gas-holder type and 2. Fixed-dome type.

1. Floating gas holder type biogas plant: This type has a well-shaped digester tank which is placed under the ground and made up of bricks. In the digester tank, over the dung slurry an inverted steel drum floats to hold the bio-gas produced. The gas holder can move which is controlled by a pipe and the gas outlet is regulated by a valve. The digester tank has a partition wall and one side of it receives the dung-water mixture through inlet pipe while the other side discharges the spent slurry through outlet pipe (Fig. 5.9).

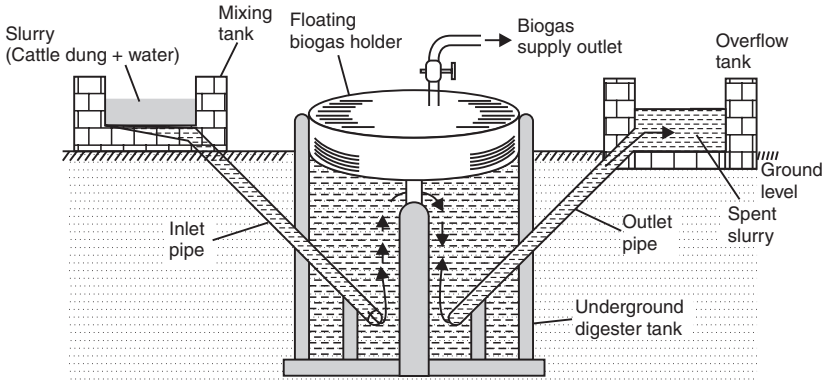


Fig. 5.9. Floating gas holder type biogas plant.

Sometimes corrosion of steel gas-holder leads to leakage of biogas. The tank has to be painted time and again for maintenance which increases the cost. Hence, another type was designed as discussed below:

2. Fixed dome type biogas plant: The structure is almost similar to that of the previous type. However, instead of a steel gas-holder there is dome shaped roof made of cement and bricks. Instead of partitioning, here there is a single unit in the main digester but it has inlet and outlet chambers as shown in Fig. 5.10.

The Ministry of Non-Conventional Energy Sources (MNES) has been promoting the biogas programme in India. Out of the various models, the important ones used in rural set-up are KVIC Model (Floating drum type), Janta Model (Fixed dome type), Deenbandhu Model (Fixed dome type), Pragati Model (Floating drum type), Ganesh Model (KVIC type but made of bamboo and polythene sheet) and Ferro-cement digester Model (KVIC type with ferro-cement digester).

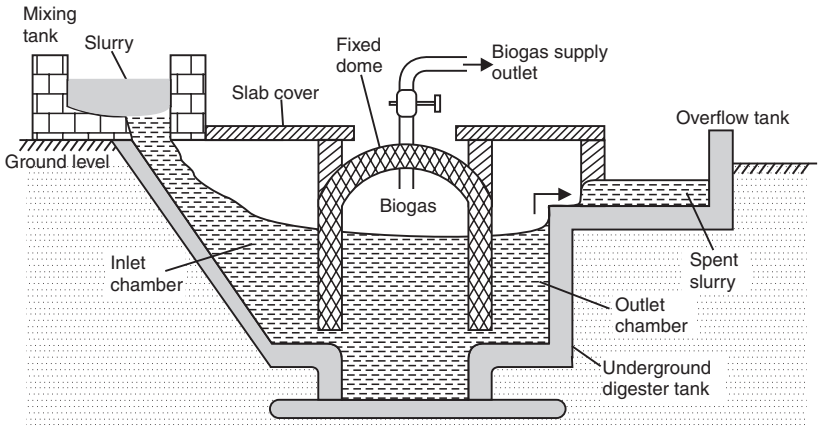


Fig. 5.10. Fixed dome type biogas plant.

5.5.5 Biofuels

Biofuels can be obtained by fermenting biomass that produces alcohols like ethanol and methanol. **Ethanol** can be easily produced from carbohydrate rich substances like sugarcane, corn and sorghum (Jowar). It burns clean and is non-polluting. However, as compared to petrol its calorific value is less and therefore, produces much less heat than petrol. It is also considered to be an excellent substitute for kerosene and its combustion is as clean as LPG. Ethanol is obtained from grain-based or sugar-containing plants like maize, cereals or even organic wastes.

Methanol is very useful since it burns at a lower temperature than gasoline or diesel. Thus the bulky radiator may be substituted by sleek designs in our cars. Methanol too is a clean, non-polluting fuel. Methanol can be easily obtained from woody plants.

Gasohol is a common fuel used in Brazil and Zimbabwe for running cars and buses. In India too gasohol is planned to be used on trial basis in some parts of the country, to start with in Kanpur. Gasohol is a mixture of ethanol and gasoline.

5.5.6 Hydrogen as a Fuel

As hydrogen burns in air, it combines with oxygen to form water and a large amount of energy (150 kilojoules per gram) is released. Due to its high, rather the highest calorific value, hydrogen can serve as an excellent fuel. Moreover, it is non-polluting and can be easily produced.

Production of hydrogen is possible by thermal dissociation, photolysis or electrolysis of water:

(*i*) By thermal dissociation of water (at 3000 K or above) hydrogen (H_2) is produced.

(*ii*) Thermochemically, hydrogen is produced by chemical reaction of water with some other chemicals in 2–3 cycles so that we do not need the high temperatures as in direct thermal method and ultimately H_2 is produced.

(*iii*) Electrolytic method dissociates water into hydrogen (H_2) and oxygen by making a current flow through it.

(*iv*) Photolysis of water involves breakdown of water in the presence of sunlight to release hydrogen. Green plants and micro-algae also carry out photolysis of water during photosynthesis. Efforts are underway to trap the hydrogen molecule which is produced during photosynthesis. Hydrogen generated by microbial systems is called **biohydrogens.**

However, hydrogen is highly inflammable and explosive in nature. Hence, safe handling is required for using H_2 as a fuel. Also, it is difficult to store and transport. And being very light, it would have to be stored in bulk.

Presently, H_2 is used in the form of liquid hydrogen as a fuel in spaceships. H_2 can be used in **fuel cell** to generate electricity. In fuel cell hydrogen is burnt in air or oxygen in the pressure of an electrolyte to produce electricity.

I. QUESTIONS

1. What are renewable and non-renewable resources? Give examples.
2. Give an account of non-renewable energy resources?
3. What are electromagnetic radiations? What are the anthropogenic sources of these radiations?
4. Discuss properties of electromagnetic radiations.
5. What are solar cells? Draw a diagram of a solar cell and enumerate its applications.
6. What is biogas? Discuss the structure and function of biogas plants.
7. What is nuclear energy? Discuss its two types.
8. What is hydro-electric energy? How is it generated?
9. Can hydrogen be used as a fuel? How can hydrogen be produced?
10. Discuss various benefits of using hydrogen as a fuel.

II. OBJECTIVE TYPE QUESTIONS

(A) FILL IN THE BLANKS

1. ..... resources are inexhaustible resources which can be generated within a given span of time.
2. ..... resources can not be generated.
3. ....., ... and ..... are the natural sources of electromagnetic radiations.
4. ....., ... and ..... are man made sources of electromagnetic radiations.
5. .....is the most abundant fossil fuel in the world.
6. ....., ... and ..... are conventional sources of energy.
7. Natural gas has high calorific value of about ..... kJ/g.
8. Biogas is produced by ..... degradation (in the absence of oxygen) of biological wastes.
9. 95% natural gas is .....
10. Gasohol is a mixture of ..... and .....

11. Nuclear energy by nuclear fission is generated when certain isotopes are bombarded by ....

12. Electrolytic method dissociates water into ..... and ..... .

(B) CHOOSE THE CORRECT ANSWER

1. Which of the following is included under non-conventional source of energy?
(*a*) Hydroelectric energy (*b*) Solar energy
(*c*) Hydrogen (*d*) All of these.

2. Which of the following are the sources of electromagnetic radiations?
(*a*) Thunder storms (*b*) Electric gadgets
(*c*) Mobile phones (*d*) All of these.

3. Biomass energy can be obtained from
(*a*) Energy plantations (*b*) Petro crops
(*c*) Agricultural and urban waste biomass
(*d*) All of these.

4. Which of the following types of coal has maximum carbon and calorific value?
(*a*) Anthracite (hard coal) (*b*) Bituminous (soft coal)
(*c*) Lignite (brown coal) (*d*) Wood coal.

5. Nuclear energy can be generated by
(*a*) Nuclear fusion (*b*) Nuclear fission
(*c*) Both of these (*d*) None of these.

(C) WRITE TRUE OR FALSE

1. It takes millions of years for formation of coal from trees. (True/False)

2. Electromagnetic radiations can travel in space without any material medium. (True/False)

3. Electromagnetic radiations have a wide range of wavelength. (True/False)

4. Solar cells are made up of thin wafers of semi-conductor materials like silicon and gallium. (True/False)

5. Solar heat can not be used to operate street lights, water pumps, television, calculators etc. (True/False)

6. Ideal location for installation of wind-mills are coastal regions, open grasslands, hilly regions. (True/False)

7. Hydropower also causes environmental pollution. (True/False)

8. Burning of dung produces biomass energy but doesn't destroy essential nutrients like N and P. (True/False)

9. Sludge left over in the biogas plant cannot be used as a fertilizer. (True/False)

10. Ethyl mercaptan (a foul smelling gas) is added to odourless LPG for instantaneous detection of any leakage. (True/False)

6

Environmental Pollution

For normal and healthy living a conducive environment is required by all living beings, including humans, livestock, plants, micro-organisms and the wildlife. The favourable unpolluted environment has a specific composition. When this composition gets changed by addition of harmful substances, the environment is called polluted environment and the substances polluting it are called pollutants. **Environmental pollution can, therefore, be defined as any undesirable change in the physical, chemical or biological characteristics of any component of the environment (air, water, soil), which can cause harmful effects on various forms of life or property.** Environmental pollution could be of various types:

6.1 WATER POLLUTION

Water pollution can be defined as alteration in physical, chemical or biological characteristics of water making it unsuitable for designated use in its natural state.

(A) Sources of Water Pollution: Water is an essential commodity for survival. We need water for drinking, cooking, bathing, washing, irrigation, and for industrial operations. Most of the water for such uses comes from rivers, lakes or groundwater sources. Water has the property to dissolve many substances in it, therefore, it can easily get polluted. Pollution of water can be caused by "point sources" or "non-point sources". Point sources are specific sites near water which directly discharge effluents into them. Major point sources of water pollution are industries, power plants, underground coal mines, offshore oil wells etc. The discharge from non-point sources is not at any particular site, rather, these sources are scattered, which individually or collectively pollute water. Surface run-off from agricultural fields, overflowing small drains, rain water sweeping roads and fields, atmospheric deposition etc., are the non-point sources of water pollution.

Ground Water Pollution: Ground water forms about 0.6% of the total water available on planet earth and is about 30 times more than surface water (streams, lakes and estuaries). Ground water seems to be less prone to pollution as the soil mantle through which water passes helps to retain various contaminants due to its cation exchange capacity. However, there are a number of potential sources of ground water pollution. Septic tanks, industry (textile, chemical, tanneries), deep well injection, mining

etc., are mainly responsible for ground water pollution, which is irreversible. Ground water pollution with arsenic, fluoride and nitrate are posing serious health hazards.

Surface water pollution: The major sources of surface water pollution are:

1. **Sewage.** Emptying the drains and sewers in fresh water bodies causes water pollution. The problem is severe in cities.
2. **Industrial effluents.** Industrial wastes containing toxic chemicals, acids, alkalis, metallic salts, phenols, cyanides, ammonia, radioactive substances, etc., are sources of water pollution. They also cause thermal (heat) pollution of water.
3. **Synthetic detergents.** Synthetic detergents used in washing and cleaning produce foam and pollute water.
4. **Agrochemicals.** Agrochemicals like fertilizers (containing nitrates and phosphates) and pesticides (insecticides, fungicides, herbicides etc.) washed by rain-water and surface run-off pollute water.
5. **Oil.** Oil spillage into sea-water during drilling and shipment pollute it.
6. **Waste heat.** Waste heat from industrial discharges increases the temperature of water bodies and affects distribution and survival of sensitive species.

(B) Effects of Water Pollution: Following are some important effects of various types of water pollutants:

Oxygen demanding wastes: Organic matter which reaches water bodies is decomposed by micro-organisms present in water. For this degradation, oxygen dissolved in water is consumed. Dissolved oxygen (DO) is the amount of oxygen dissolved in a given quantity of water at a particular temperature and atmospheric pressure. Amount of dissolved oxygen depends on aeration, photosynthetic activity in water, respiration of animals and plants and ambient temperature.

The saturation value of DO varies from 8–15 mg/L. For active fish species (trout and Salmon) 5–8 mg/L of DO is required whereas less desirable species like carp can survive at 3.0 mg/L of DO.

Lower DO may be harmful to animals especially fish population. Oxygen depletion (deoxygenation) helps in release of phosphates from bottom sediments and causes eutrophication.

Nitrogen and phosphorus compounds (nutrients): Addition of compounds containing nitrogen and phosphorus helps in the growth of algae and other plants which when die and decay consume oxygen of water. Under anaerobic conditions foul smelling gases are produced. Excess growth or decomposition of plant material will change the concentration of CO_2 which will further change pH of water. Changes in pH, oxygen and temperature will change many physico-chemical characteristics of water.

Pathogens: Many waste waters especially sewage contain many pathogenic (disease causing) and non-pathogenic micro-organisms and many viruses. Water borne diseases like cholera, dysentery, typhoid, jaundice etc. are spread by water contaminated with sewage. Detailed accont has been given in chapter IV.

Toxic compounds: Pollutants such as heavy metals, pesticides, cyanides and many other organic and inorganic compounds are harmful to aquatic organisms.

The demand of DO increases with addition of biodegradable organic matter which is expressed as biological oxygen demand (BOD). BOD is defined as the amount of DO required to aerobically decompose biodegradable organic matter of a given volume of water over a period of 5 days at 20ºC. Higher BOD values of any water sample are associated with poor water quality. The non-biodegradable toxic compounds biomagnify in the food chain and cause toxic effects at various levels of food chain.

Some of these substances like pesticides, methyl mercury etc., move into the bodies of organisms from the medium in which these organisms live. Substances like DDT are not water soluble and have affinity for body lipids. These substances tend to accumulate in the organism's body from the medium food. This process is called **bioaccumulation** or **bioconcentration.** The concentration of these toxic substances builds up at successive levels of food chain. This process is called **biomagnification.** Following is the example of biomagnification of DDT in aquatic food chain:

Component	**DDT concentration (ppm)**
Birds	10.00
↑	↑
Needle fish	1.0
↑	↑
Minnows	0.1
↑	↑
Zooplankton	0.01
↑	↑
Water	0.000001

Toxic substances polluting the water ultimately affect human health. Some heavy metals like lead, mercury and cadmium cause various types of diseases. Mercury dumped into water is transformed into water soluble methyl mercury by bacterial action. Methyl mercury accumulates in fish. In 1953, people in Japan suffered from numbness of body parts, vision and hearing problems and abnormal mental behaviour. This disease called **Minamata disease** occurred due to consumption of methyl mercury contaminated fish caught from Minamata Bay in Japan. The disease claimed 50 lives and permanently paralysed over 700 persons. Pollution by another heavy metal cadmium had caused the disease called **Itai-itai** in the people of Japan. The disease was caused by cadmium contaminated rice. The rice fields were irrigated with effluents of zinc smelters and drainage water from mines. In this disease bones, liver, kidney, lungs, pancreas and thyroid are affected.

Lead in water may be released from water pipes as lead is used in plumbing. Lead poisoning affects kidneys reproductive system, liver, brain and central nervous system. It also causes anemia and mental retardation in children.

Arsenic Pollution of Ground Water

Arsenic Pollution in Groundwater: West Bengal and Bangladesh are severely contaminated by the toxic heavy metal arsenic. The first report of arsenic pollution in West Bengal came in 1978 and that of Bangladesh in 1993, where it was found to be even more widespread. Arsenic poisoning has far reaching consequences. The local people were found to be ingesting low doses of arsenic for 10–14 years after which suddenly white or black spots called melanosis started mottling the skin. The spots were later found to get converted into leprosy like skin lesions encrusting the palms and soles, eventually rotting into gangrenous ulcers. Long exposures often led to bladder and lung cancer. Children are more badly affected by arsenicosis, the affected people are socially isolated, children barred from attending schools and young women remain single or have broken marriages. The WHO has prescribed the maximum permissible limits of arsenic as 10 mg/L. In West Bengal 40 million out of 90 million people are feared to have likely exposure to arsenic threat due to contaminated water. The 24 Paraganas, Hooghly and Murshidabad districts as also Behala and South Eastern fringes of Kolkata lie in Arsenic Risk Zone. Earlier it was postulated that arsenic has entered into groundwater due to geologic reasons in the Ganga Delta. Recently, however, it is being linked with anthropogenic causes.

Excessive use of lead arsenate and copper arsenite as pesticides in high yielding varieties of summer paddy and jute crop seems to be the major cause of arsenic pollution. Now the arsenic contaminated tubewells in the state are being painted red while safe water tubewells are painted green for use by people.

Nitrate ions present in the water are harmful to human health. From nitrogen fertilizers, nitrate ions seep into water bodies from where these may bioaccumulate in the bodies of the consumers. In the stomach nitrate is reduced to nitrite and is responsible for **blue baby syndrome** and stomach cancer. Young children less than 1 year of age when ingest excessive nitrate, nitrite is formed in their stomach by microbes as the stomach is not acidic to the extent to inhibit the microbes. Which bring about this conversions. Nitrite reacts with haemoglobin which is converted into non-functional oxidised form. Due to diarrhoea and vomitting child becomes slate blue, giving the baby blue baby syndrome or **methaemoglobinaemia**.

Nitrate in the stomach of adult humans partly converts into nitrite. Nitrite interacts with secondary amines to produce N-nitrosamine which in experimental animals have been shown to cause stomach cancer. In human beings, however, evidences do not show association of nitrate with cancer.

Fluoride pollution causes defects in teeth and bones, a disease called **fluorosis.** Details have been given in chapter 4. Pesticides through drinking water reach humans and are known to cause various health problems. The organophosphorus and carbamate pesticides are more toxic. Organochlorine pesticides accumulate in the body and affect various organs especially the central nervous system. These pesticides stimulate liver enzymes which results in rapid metabolism of drugs in the person who is on medication. The effectiveness of medicines will be reduced.

Since some pesticide accumulate in the body, these may be transferred to young babies with the mothers's milk. Due to their persistence DDT, aldrin, dieldrin etc. have been banned in many countries. Some years ago people in Andhra Pradesh suffered from various abnormalities due to consumption of endosulphan contaminated cashew nuts.

(C) Remedial Measures for Water Pollution (Control): It is easy to reduce water pollution from point sources by legislation. However, due to absence of defined strategies it becomes difficult to prevent water pollution from non-point sources. The following points may help in reducing water pollution from non-point sources.

(*i*) Judicious use of agrochemicals like pesticides and fertilizers which will reduce their surface run-off and leaching. Use of these on sloped lands should be avoided.

(*ii*) Use of nitrogen fixing plants to supplement the use of fertilizers.

(*iii*) Adopting integrated pest management to reduce greater reliance on pesticides.

(*iv*) Prevent run-off of manure. Divert such run-off to basin for settlement. The nutrient rich water can be used as fertilizer in the fields.

(*v*) Separate drainage of sewage and rain water should be provided to prevent overflow of sewage with rain water.

(*vi*) Planting trees would reduce pollution by sediments and will also prevent soil erosion.

For controlling water pollution from point sources, treatment of waste waters is essential before being discharged. Parametres which are considered for reduction in such water are:

Total solids, biological oxygen demand (BOD), chemical oxygen demand (COD), nitrates and phosphates, oil and grease, toxic metals etc.

Waste waters should be properly treated by primary and secondary treatments to reduce the BOD, COD levels upto the permissible levels for discharge.

6.2 LAND POLLUTION

(A) Sources of Land Pollution: Soil is the upper layer of the earth crust which is formed by weathering of rocks. Organic matter in the soil makes it suitable for living organisms. Dumping of various types of materials especially domestic and industrial wastes causes land pollution. Domestic wastes include garbages, rubbish material like glass, plastics, polythene bags, metallic cans, paper, fibres, cloth rags, containers, paints, varnishes etc. Leachates from dumping sites and sewage tanks are harmful and toxic, which pollute the soil. Polythene does not degrade and becomes brittle in due course. It affects the porosity of the soil.

Industrial wastes are the effluents discharged from chemical industries, paper and pulp mills, tanneries, textile mills, steel industries, distilleries, refineries, pesticides and fertilizer industries, pharmaceutical industries, food processing industries, cement industries, thermal and nuclear power plants, mining industries etc. Thermal power plants generate a large quantity of 'Fly ash'. Huge quantities of these wastes are dumped on land which cause land pollution.

Pesticides are used to kill pests that damage crops. These pesticides ultimately reach the soil and persist there for a long time. Pesticides which are persistent in nature are chlorinated hydrocarbon insecticides *e.g.,* DDT, HCH, endrin, lindane, heptachlor, endosulfan etc. Residues of these pesticides in soils have long term effects especially under the temperate conditions.

Industrial wastes also contain some organic and inorganic compounds that are refractory and non-biodegradable. Industrial sludge may contain various salts, toxic substances, metals like mercury, lead, cadmium, arsenic etc. Agrochemicals released with the wastes of pesticide and fertilizer factories or during agricultural practices also reach land and pollute it.

Land also receives excreta from animals and humans. The sewage sludge contains many pathogenic organisms, bacteria, viruses and intestinal worms which cause pollution of the land.

The sources of radioactive substances in soil are explosion of radioactive devices, radioactive wastes discharged from industries and laboratories, aerial fall-out etc. Isotopes of radium, uranium, thorium, strontium, iodine, caesium and of many other elements reach land and persist there for a long time and keep on emitting radiations.

(B) Effects of Land Pollution: Sewage and industrial effluents which pollute land ultimately affect human health. Various types of chemicals like acids, alkalis, pesticides, insecticides, weedicides, fungicides, heavy metals etc., in the industrial discharges affect soil fertility by causing changes in physical, chemical and biological properties.

Some of the persistent toxic chemicals inhibit the non-target organisms, soil flora and fauna and reduce soil productivity. These chemicals accumulate in food chain and ultimately affect human health. Indiscriminate use of pesticides specially is a matter of concern.

Sewage sludge has many types of pathogenic bacteria, viruses and intestinal worms which may cause various types of diseases. Decomposing organic matter in soil also produces toxic vapours.

Radioactive fallout on vegetation is the source of radio-isotopes which enter the food chain in the grazing animals. Some of these radio-isotopes replace essential elements in the body and cause abnormalities *e.g.* strontium-90 instead of calcium gets deposited in the bones and tissues. The bones become brittle and prone to fracture.

Radio-isotopes which attach with the clay become a source of radiations in the environment.

Nitrogen and phosphorus from the fertilizers in land reach nearby water bodies with agricultural run-off and cause **eutrophication.** Chemicals or their degradation product from land may percolate and contaminate ground water resources.

(C) Control of Land Pollution

(*i*) Effluents should be properly treated before discharging them on land.

(*ii*) Solid wastes should be properly collected and disposed off by appropriate method.

(*iii*) From the wastes, recovery of useful products should be done.

(*iv*) Biodegradable organic waste should be used for generation of biogas.

(*v*) Cattle dung should be used for methane generation. Night-soil (human faeces) can also be used in the biogas plant to produce inflammable methane gas.

(*vi*) Microbial degradation of biodegradable substances is also one of the scientific approaches for reducing land pollution.

6.3 NOISE POLLUTION

We hear various types of sounds everyday. Sound is mechanical energy from a vibrating source. A type of sound may be pleasant to someone and at the same time unpleasant to others. The unpleasant and unwanted sound is called noise.

Sound can propagate through a medium like air, liquid or solid. Sound wave is a pressure perturbation in the medium through which sound travels. Sound pressure alternately causes compression and rarefaction. The number of compressions and rarefaction of the molecules of the medium (for example, air) in a unit time is described as frequency. It is expressed in Hertz (Hz) and is equal to the number of cycles per second.

There is a wide range of sound pressures, which encounter human ear. Increase in sound pressure does not invoke linear response of human ear. A meaningful logarithmic scale has been devised. The noise measurements are expressed as Sound Pressure Level (SPL) which is logarithmic ratio of the sound pressure to a reference pressure. It is expressed as a dimensionless unit, decibel (dB). The international reference pressure of 2×10^{-5} Pa is the average threshold of hearing for a healthy ear. Decibel scale is a measure of loudness. Noise can affect human ear because of its loudness and frequency (pitch).

The Central Pollution Control Board (CPCB) has recommended permissible noise levels for different locations as given in Table 6.1.

Table 6.1. Noise Standards Recommended by CPCB Committee

Area code	*Category of area*	*Noise level in dB(A) Leq*	
		Day	*Night*
(A)	Industrial	75	70
(B)	Commercial	65	55
(C)	Residential	55	45
(D)	Silence zone	50	40

Table 6.2. Different Sounds and their Sound Levels on Decibel Scale

Sound level (dB)			*Source of sound*
	180	—	Rocket engine
	170		
	160		
	150	—	Jet plane take off
Threshold of pain —	140		
	130	—	Maximum recorded rock music
	120	—	Thunder cap
	110	—	Autohorn 1 m away
	100	—	Jet fly over at 300 m, construction work, newspaper press
	90	—	Motor cycle/8 m away, food blender
	80		
	70	—	Vacuum cleaner, ordinary conversation
	60	—	Air conditioning unit, 6 m away; light traffic noise, 30 m away
	50	—	Average living room
	40		
	30	—	Library, soft whisper
	20	—	Broadcasting studio
	10	—	Rustling leaf
Threshold of hearing —	0		

(A) Sources of Noise Pollution: The sources of noise can be classified as (*i*) Mobile sources and (*ii*) Stationary sources. (*i*) Mobile sources are various modes of transportation (like air, road, rail-transportation) and (*ii*) Stationary sources include industrial operations, construction activities and celebrations (social/religious functions, elections etc.), electric home appliances etc.

High levels of noise have been recorded in some of the cities of the world. In Nanjing (China) noise level of 105 dB has been recorded, while in some other cities of the world these levels are: Rome 90 dB, New York 88 dB, Kolkata 85 dB, Mumbai 82 dB, Delhi 80 dB, Kathmandu 75 dB.

(B) Effects of Noise Pollution: Noise pollution causes the following effects:

(i) **Interferes with man's communication:** In a noisy area communication is severely affected.

(ii) **Hearing damage:** Noise can cause temporary or permanent hearing loss. It depends on intensity and duration of sound level. Auditory sensitivity is reduced with noise level for over 90 dB in the mid-high frequency for more than a few minutes.

(iii) **Physiological and psychological changes:** Continuous exposure to noise affects the functioning of various systems of the body. It may result in hypertension, insomnia (sleeplessness), gastro-intestinal and digestive disorders, peptic ulcers, blood pressure changes, behavioural changes, emotional changes etc.

(C) Noise Pollution During Diwali: Diwali is a festival of lights. Traditionally people of all ages enjoy firecrackers. Some accidents do occur every year claiming a few lives. Besides, noise generated by various firecrackers is beyond the permissible noise levels of 125 decibels as per the Environmental (Protection) (Second Amendment) Rules, 1999.

There has been a great concern over the noise levels generated during Diwali. Some measurements by certain group of researchers have also been made at various places during Diwali. It is recommended that the manufacturers of fireworks should mention the noise levels in decibels generated by individual items. The department of explosives of the Union Ministry of Commerce and Industry is entrusted with the task to ensure that the industry produces firecrackers conforming to permissible noise standards.

According to a test report on firecrackers produced by the National Physical Laboratory, New Delhi most of the firecrackers available in the market produce noise beyond the permissible levels of 125 decibels as per the Environment (Protection) (Second amendment) Rules, 1999. Some of them have been observed to produce noise near the threshold of pain. The details are given in Table 6.3.

Table 6.3. Noise Levels Generated by Firecrackers

Types of firecracker	*Manufacturer*	*Generated noise level in decibels*
Atom bomb (timing bomb)	Coronation Fireworks, Sivakasi	135 ± 2
Chinese crackers (a string of 1,000 in one piece)	Sri Kaliswari Fireworks, Sivakasi	128
Chinese crackers (a string of 600 in one piece)	Sri Kaliswari Fireworks, Sivakasi	132
Nazi (atom bomb)	Coronation Fireworks, Sivakasi	135 ± 0
Magic formula (flower bomb)	Rajan Fireworks, Sivakasi	136 ± 1
Atom bomb (foiled)	Sri Kaliswari Fireworks, Sivakasi	131 ± 2
Hydrogen bomb	Sri Patrakali Fireworks, Sivakasi	134 ± 2
Rajan classic dhamaka (foiled bomb)	Rajan Fireworks, Sivakasi	136 ± 0
Samrat classic bomb (deluxe)	Venkateswara Fireworks, Sivakasi	136 ± 0
Hydro foiled (bomb)	Sri Kaliswari Fireworks, Sivakasi	132 ± 2
*Three sound (bomb)	Coronation Fireworks, Sivakasi	119 ± 7
Atom bomb	Local	136 ± 0

*Cracker meeting the noise pollution standards.

Source: Test report on firecrackers, National Physical Laboratory, New Delhi, April 21, 2003.

The noise levels were measured under standard conditions *i.e.* in areas not having noise-reflecting surfaces within a 15 metre radius. Two gadgets, for measuring sound levels were installed at a height of 1.3 metres and at a distance of 4 metres from the source of sound.

Besides mentioning the sound levels on each of the types of firecrackers or banning the production of such firecrackers which produce noise above permissible levels, it is important to educate people about the harmful effects of noise during such festivals like Diwali. It can be done by giving public notices in the leading newspapers and messages through other mass media like radio and television.

Honourable Supreme Court in a Writ Petition (civil) of 1998 concerning noise pollution had passed the following directions as an interim measure.

The Union Government, The Union Territories as well as all the State Governments shall in particular comply with amended Rule 89 of the Environmental (Protection) Rules, 1986 framed under the Environmental (Protection) Act, 1986 which essentially reads as follows:

1. (*i*) The manufacture, sale or use of firecrackers generating noise level exceeding 125 dB (AI) or 145 dB (C) pk at 4 meters distance from the point of bursting shall be prohibited.

   (*ii*) For individual firecracker constituting the series (joined firecrackers), the above mentioned limit be reduced by 5 log 10 (N) dB, where N = Number of crackers joined together.

2. The use of fireworks or firecrackers shall not be permitted except between 6.00 p.m. and 10.00 p.m. No fireworks or firecrackers shall be used between 10.00 p.m. and 6.00 a.m.

3. Firecrackers shall not be used at any time in silence zones, as defined by the Ministry of Environment and Forests. Silence Zone has been defined as:

"Silence Zone in an area comprising not less that 100 meters around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority."

4. The State Education Resource Centres in all the States and Union Territories as well as the management/principals of schools in all the States and Union Territories shall take appropriate steps to educate students about the ill effects of air and noise pollution and apprise them of directions (1) to (3) above.

(D) Remedial Measures for Noise Pollution (Control)

1. *Reduction in sources of noise*: Sources of noise pollution like heavy vehicles and old vehicles may not be allowed to ply in the populated areas.
2. Noise making machines should be kept in containers with sound absorbing media. The noise path will be uninterrupted and will not reach the workers.
3. Proper oiling will reduce the noise from the machinery.
4. *Use of sound absorbing silencers*: Silencers can reduce noise by absorbing sound. For this purpose various types of fibrous material could be used.
5. Planting more trees having broad leaves.
6. *Through law*: Legislation can ensure that sound production is minimised at various social functions. Unnecessary horn blowing should be restricted especially in vehicle-congested areas.

6.4 PUBLIC HEALTH ASPECTS

Various aspects concerning protection and promotion of healthy human environment including water, air, food, shelter and working areas are known as public health aspects. For promotion of public health, diverse knowledge inputs from various fields like ecology, microbiology, pathology, entomology, epidemiology, human physiology and engineering are required. Public health basically deals with water supply, sewerage and sewage disposal, drainage system, refuse sanitation, ventilation, air conditioning, and air pollution abatement and prevention of outbreak of diseases like malaria, dengue, encephalitis etc. The engineers of public health department apply engineering principles for sanitation of the environment.

6.4.1 Public Water Supply

All our public water supplies should be free from various types of impurities and the water should meet the drinking water quality standards prescribed by agencies like Bureau of Indian Standards (BIS). World Health Organization (WHO) or Indian Council of Medical Research (ICMR).

In ancient times mainly ground water was used that was derived from wells or springs. Since groundwater moves through porous strata of sediments of the soil, it was largely filtered and pure. When surface waters were to be used, these were made to stay in impounding reservoirs so that the impurities settled down. Then, **filtration** through beds of sand and gravel was used followed by flocculation using alum. This process was known as **coagulation.** However, the filtered and coagulated water is still not free of microbes responsible for spreading various diseases like cholera, typhoid, dysentery etc. Therefore, **disinfection** of water becomes a very important step in public water supply systems.

Some important methods of disinfection are:

(*i*) **Chlorination.** Chlorine or chlorinous compounds like bleaching powder [$Ca(OCl)_2$] or sodium hypochlorite (Na OCl) are used for chlorination. The dosage of chlorine has to be determined first, because too little chlorine is ineffective, while too much may cause bad taste and odour and objectionable complexes.

(*ii*) **Ozonation.** Ozone (O_3), while changing into its stable molecular form (O_2) releases nascent oxygen (O). The high oxidizing power of ozone destroys bacterial spores, without causing bad taste or odour.

(*iii*) **UV-rays.** Ultraviolet (UV) rays are powerful disinfectant. The rays are generated by passing electric current through mercury vapour lamp enclosed in quartz bulb. Water is passed over the lamp. Though it causes no objectionable taste and odour, but has limited application due to high cost.

(*iv*) **Iodine and bromine.** These are quite cheap, and have disinfecting power. However, they give a clinical taste to water.

(*v*) **Potassium permanganate.** This is an effective disinfectant due to its oxidizing property and has been found to be effective against cholera only.

(*vi*) **Copper sulphate treatment.** It is mainly used to control algal growth in water supply system.

(*vii*) **Activated carbon.** It is the most important method for control of taste and odour. It is very porous and can remove majority of the dissolved impurities in water. It also acts as an agent to remove excess chlorine, phenolic taste and colour from water.

To make water easily accessible, a well laid-out system of water distribution involving pipes, valves and other fixtures of appropriate design and capacity are required.

6.4.2 Sewerage and Sewage Disposal

The wastewater originating from community usage including domestic, industrial and storm water is termed as **sewage.** The underground conduit used for carrying and removing the sewage is known as **sewerage.**

The sewage is split up solid, liquid and gaseous components. The semi solid part (sludge) is dried, buried or dumped, or may be used as a fertilizer. The liquid part is used in ferti-irrigation projects. The gases (like methane) may be used as an energy source.

The sewer systems are of different types:

(*i*) **Separate System.** The domestic sewage and industrial wastewater are carried in one set of sewers, whereas storm water and surface water are in another set.

(*ii*) **Combined System:** All the above types of wastewaters are carried through the same set. Sometimes partially separate systems are used, where domestic sewage, industrial sewage and also a part of surface water drained from roof tops and streets are carried through same sewer.

A proper sewerage system is designed keeping into consideration the population (present and future), type of area served (population density, land-use pattern), rate of water supply and ground water infiltration (depending upon nature of soil, depth of sewer, types of material used etc.).

The fresh sewage gives obnoxious smell and is a breeding ground for pathogens. Therefore, public health department takes care for proper decomposition of the sewage.

First aerobic bacteria are made to break down the complex organic matter in the presence of some oxygen. This is followed by **putrefaction**, when anaerobic bacteria break down the organic compounds, releasing CO_2, H_2S, NH_3 and CH_4. Once again aerobic bacteria carry out oxidation leading to formation of stable compounds with little odour. Septic tanks, Inhoff tanks and sludge digestion tanks carry out putrefaction, whereas contact beds, trickling filters and aeration tanks are meant for oxidation.

6.4.3 Drainage System

A proper drainage system is required to quickly remove all foul and waste matter from various fixtures. Some important considerations are:

(*i*) The passage of gases and odour from the sewer into the building must be prevented.

(*ii*) The drainage pipes should be strong, durable, corrosion resistant, air-tight and gas-tight.

(*iii*) The pipe joints should be leak-proof.

(*iv*) There should be ample means for cleaning and removal of obstruction from entire network of pipes.

6.4.4 Environmental Sanitation

It involves a system where the solid organic waste (refuse) is properly disposed off or converted into compost. Disposal may be done in dump-sites or sanitary landfills.

In houses or working places, proper ventilation and air conditioning is done to control temperature, humidity movement of air and clean and comfortable atmosphere. Another important environmental sanitation aspect is the prevention of outbreak of diseases. Spraying or fogging is done to kill the adult or larvae of mosquitoes or other vectors (carriers) of diseases like malaria, dengue etc. Animal wastes is also utilized for generation of biogas in villages and towns in big biogas plants.

6.5 AIR POLLUTION

It is an atmospheric condition in which certain substances (including the normal constituents in excess) are present in such concentrations which can cause undesirable effects on man and his environment. These substances include gases, particulate matter, radioactive substances etc.

Gaseous pollutants include oxides of sulphur (mostly, SO_2, SO_3) oxides of nitrogen (mostly, NO and NO_2 or NO_x), carbon monoxide (CO), volatile organic compounds (mostly, hydrocarbons) etc. Particulate pollutants include smoke, dust, soot, fumes, aerosols, liquid droplets, pollen grains etc.

Radioactive pollutants include radon-222, iodine-131, strontium-90, plutonium-239 etc.

Classification of Air Pollutants

Air pollutants may occur in gaseous or particulate form and may be organic or inorganic in nature. On the basis of origin of pollutants they can be classified as primary or secondary pollutants.

Primary pollutants: These are emitted directly from the point source (identifiable source) *e.g.* carbon monoxide (CO), oxides of nitrogen (NO_x), oxides of sulphur (SO_x), hydrocarbons, radioactive substances etc.

Secondary pollutants: These are formed by interaction of primary pollutant(s) with other primary pollutant(s) or with some natural constituents of the atmosphere, *e.g.* ozone (O_3), peroxyacetyl nitrate (PAN), photochemical smog etc.

(A) Causes/Sources of Air Pollutants: The sources of air pollution are natural and man-made (anthropogenic).

- **Natural Sources:** The natural sources of air pollution are volcanic eruptions, forest fires, sea salt sprays, biological decay, photochemical oxidation of terpenes, marshes, extra terrestrial bodies, pollen grains of flowers, spores etc. Radioactive minerals present in the earth crust are the sources of radioactivity in the atmosphere.
- **Man-made:** Man-made sources include thermal power plants, industrial units, vehicular emissions, fossil fuel burning, agricultural activities etc. Thermal power plants have become the major sources for generating electricity in India as the nuclear power plants couldn't be installed as planned. The main pollutants emitted are fly ash and SO_2. Metallurgical plants also consume coal and produce similar pollutants. Fertilizer plants, smelters, textile mills, tanneries, refineries, chemical industries, paper and pulp mills are other sources of air pollution.

Automobile exhaust is another major source of air pollution. Automobiles release gases such as carbon monoxide (about 77%), oxides of nitrogen (about 8%) and hydrocarbons (about 14%). Heavy duty diesel vehicles spew more NO_x and suspended particulate matter (SPM) than petrol vehicles which produce more carbon monoxide and hydrocarbons.

Indoor air pollution: The most important indoor air pollutant is radon gas. Radon gas and its radioactive daughters are responsible for a large number of lung cancer deaths each year. Radon can be emitted from building materials like bricks, concrete, tiles etc., which are derived from soil containing radium. Radon is also present in groundwater and natural gas and is emitted indoors while using them.

Many houses in the under-developed and developing countries including India use fuels like coal, dung-cakes, wood and kerosene in their kitchens. Complete combustion of fuel produces carbon dioxide which may not be toxic. However, incomplete combustion produces the toxic gas carbon monoxide. Coal contains varying amounts of sulphur which on burning produces sulphur dioxide. Fossil fuel burning produces black soot. These pollutants i.e. CO, SO_2, soot and many others like formaldehyde, benzo-(*a*) pyrene (BAP) are toxic and harmful for health. BAP is also found in cigarette smoke and is considered to cause cancer. A housewife using wood as fuel for cooking inhales BAP equivalent to 20 packets of cigarette a day.

(B) Effects of Air Pollution: Air pollution has adverse effects on living organisms and materials.

- **Effects on human health.** Human respiratory system has a number of mechanisms for protection from air pollution. Bigger particles (> 10 μm) can be trapped by the hairs and sticky mucus in the lining of the nose. Smaller particles can reach tracheobronchial system and there get trapped in mucus. They are sent back to throat by beating of hair like cilia from where they can be removed by spitting or swallowing. Years of exposure to air pollutants (including cigarette smoke) adversely affects these natural defences and can result in lung cancer, asthma, chronic bronchitis and emphysema (damage to air sacs leading to loss of lung elasticity and acute shortness of breath). Suspended particulates can cause damage to lung tissues and diseases like asthma, bronchitis and cancer especially when they bring with them cancer causing or toxic pollutants attached on their surface. Sulphur dioxide (SO_2) causes constriction of respiratory passage and can cause bronchitis like conditions. In the presence of suspended particulates, SO_2 can form acid sulphate particles, which can go deep into the lungs and affect them severely.

Oxides of nitrogen especially NO_2 can irritate the lungs and cause conditions like chronic bronchitis and emphysema. Carbon monoxide (CO) reaches lungs and combines with haemoglobin of blood to form carboxyhaemoglobin. CO has affinity for haemoglobin 210 times more than oxygen. Haemoglobin is, therefore, unable to transport oxygen to various parts of the body. This causes suffocation. Long exposure to CO may cause dizziness, unconsciousness and even death.

Many other air pollutants like benzene (from unleaded petrol), formaldehyde and particulates like polychlorinated biphenyls (PCBs), toxic metals and dioxins (from burning of polythene) can cause mutations, reproductive problems or even cancer.

Many other hazardous materials like asbestos, beryllium, mercury, arsenic and radioactive substances cause lung diseases and/or affect other vital organs like kidney, liver, spleen, brain and some may also cause cancer.

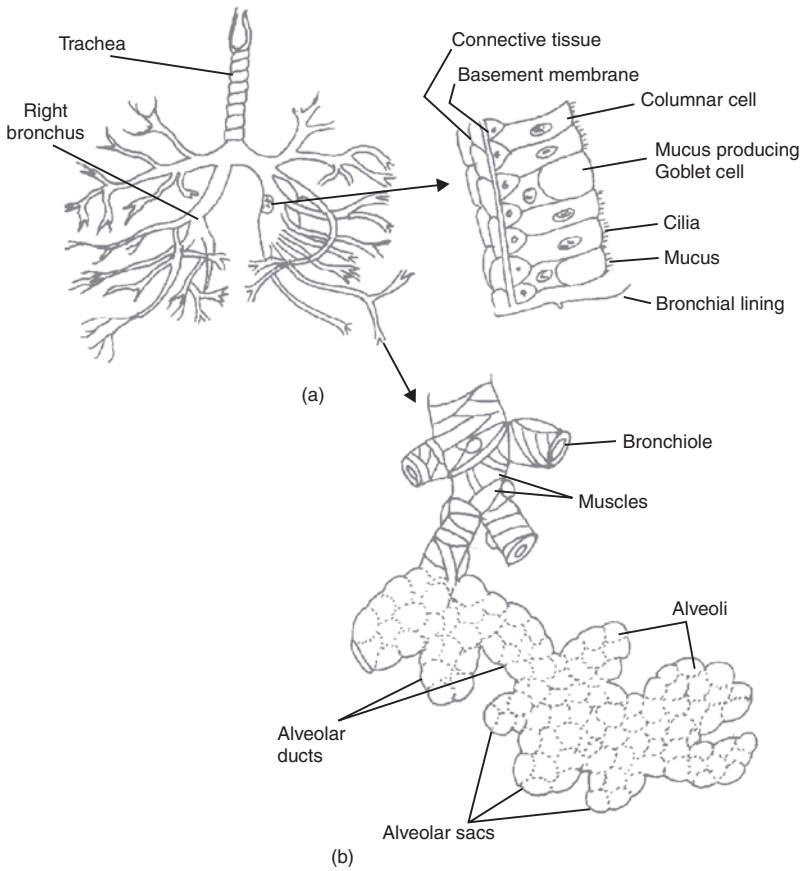


Fig. 6.1. Lower respiratory system of human beings (a and b) and cross-section of bronchial lining showing cilia and goblet cells.

- **Effects on plants:** Air pollutants affect plants by entering through stomata (leaf pores through which gases diffuse), destroy chlorophyll and affect photosynthesis. During the day time the stomata are wide open to facilitate photosynthesis. Air pollutants during day time affect plants by entering the leaf through these stomata more than night. Pollutants also erode waxy coating of the leaves called cuticle. Cuticle prevents excessive water loss and damage from diseases, pests, drought and frost. Damage to leaf structure causes ***necrosis*** (dead areas of leaf), ***chlorosis*** (loss or reduction of chlorophyll causing yellowing of leaf) or ***epinasty*** (downward curling of leaf), and ***abscission*** (dropping of leaves). Particulates deposited on leaves can form encrustations and plug the stomata and also reduce the availability of sunlight. The damage can result in death of the plant.

SO_2 causes bleaching of leaves, chlorosis, injury and necrosis of leaves. NO_2 results in increased abscission and suppressed growth. O_3 causes flecks on leaf surface, premature aging, necrosis and bleaching. Peroxyacetyl nitrate (PAN) causes silvering of lower surface of leaf, damage to young and more sensitive leaves and suppressed growth. Fluorides cause necrosis of leaf-tip while ethylene results in epinasty, leaf abscission and dropping of flowers.

- **Effects on aquatic life:** Air pollutants mixing up with rain can cause high acidity (lower pH) in fresh water lakes. This affects aquatic life especially fish. Some of the fresh water lakes have experienced total fish death.
- **Effects on materials:** Because of their corrosiveness, particulates can cause damage to exposed surfaces. Presence of SO_2 and moisture can accelerate corrosion of metallic surfaces due to formation of sulfuric acid. Metal parts of buildings, vehicles, bridges, wires and metallic railway tracks are affected. Sulfuric acid also damages buildings and causes disfigurement of statues made up of marble and limestone. Sulfuric acid formed by the atmospheric SO_2 and water vapours damages the leather binding of books. The pages of the books also become brittle. SO_2 can affect fabric, leather, paint and paper. Ozone in the atmosphere can cause cracking of rubber. Nylon stockings are weakened and ultimately damaged. Tyres of various vehicles are also damaged. These days chemicals are added to prevent damage to tyre rubber by ozone. Oxides of nitrogen and ozone can also cause fading of cotton and rayon fibres.

(C) Remedial Measures for Air Pollution (Control): Air pollution can be minimised by the following methods:

- Siting of industries after proper environmental impact assessment studies.
- By dilution of emission. This can be done by increasing the stack height (though up to permissible height), beyond inversion layer. Wind currents will disperse the pollutants.

  But this results in interstate dispute and is not considered to be solution for air pollution problem.
- Minimise/modify activities which cause pollution *e.g.* transportation and energy production.
- Modification of process and/or equipment.
- Use of appropriate material.
- Using low sulphur coal in industries.
- Removing sulphur from coal (by washing or with the help of bacteria).
- Removing NO_x during the combustion process and controlling the flow of air and fuel in industrial boilers.
- Vehicular pollution can be checked by regular tune-up of engines; replacement of more polluting old vehicles; installing catalytic converters; by engine modification to have fuel efficient (lean) mixtures to reduce CO and hydrocarbon emissions; and slow and cooler burning of fuels to reduce NO_x emission (Honda Technology).
- Using mass transport system, bicycles etc.
- Shifting to less polluting (clean) fuels (hydrogen gas).
- Using non-conventional sources of energy.
- Using biological filters and bio-scrubbers.
- Planting more trees.
- Reduction of pollution at source by installing air pollution control devices like cyclones, baghouse filters, wet scrubbers, electrostatic precipitators etc.

6.6 SOLID WASTE MANAGEMENT

Higher standards of living of ever increasing population has resulted in an increase in the quantity and variety of waste generated. It is now realized that if waste generation continues indiscriminately then very soon it would be beyond rectification. Management of solid waste has, therefore, become very important in order to minimize the adverse effects of solid wastes. Solid waste (waste other than liquid or gaseous) can be classified as municipal, industrial, agricultural, medical, mining waste and sewage sludge.

(A) Sources of Urban and Industrial Wastes: Urban waste consists of medical waste from hospitals; municipal solid wastes from homes, offices, markets (commercial waste) small cottage units, and horticulture waste from parks, gardens, orchards etc.

- **Waste from homes (Domestic waste)** contains a variety of discarded materials like polyethylene bags, empty metal and aluminium cans, scrap metals, glass bottles, waste paper, diapers, cloth/rags, food waste, electronic waste (e-waste).
- **Waste from shops** mainly consists of waste paper, packaging material, cans, bottles, polyethylene bags, peanut shells, egg shells, tea leaves etc.
- **Biomedical waste** includes anatomical wastes, pathological wastes, infectious wastes etc.
- **Construction/demolition waste** includes debris and rubbles, wood, concrete etc.
- **Horticulture waste and waste from slaughter houses** include vegetable parts, residues and remains of slaughtered animals, respectively.

The urban solid waste materials that can be degraded by micro-organisms are called **biodegradable wastes**. Examples of this type of waste are vegetable wastes, stale food, tea leaves, egg shells, peanut shells, dry leaves etc. Wastes that cannot be degraded by micro-organisms are called **non-biodegradable wastes**. For example, polyethylene bags, scrap metal, glass bottles etc.

- **Industrial waste:** Industrial waste consists of a large number of materials including factory rubbish, packaging material, organic wastes, acids, alkalis and metals etc. During some industrial processing large quantities of hazardous and toxic materials are also produced. The main sources of industrial wastes are chemical industries, metal and mineral processing industries. Radioactive wastes are generated by nuclear power plants. Thermal power plants produce fly ash in large quantities. Solid wastes from other types of industries include scrap metal, rubber, plastic, paper, glass, wood, oils, paints, asphalt, tars, dyes, scrap leather, ceramics, abrasives, slag, heavy metals, asbestos, batteries. In Europe and North America the environmental laws and safety laws are becoming more stringent due to which disposal of hazardous wastes is becoming a problem. Cost of disposal of such wastes is increasing. Therefore, these wastes are being exported to developing countries which do not even have sufficient knowledge or technique for their disposal.

(B) Effects of Solid Wastes: Municipal solid wastes heap up on the roads due to improper disposal system. People clean their own houses and litter their immediate surroundings which affects the community including themselves. This type of dumping allows biodegradable materials to decompose

under uncontrolled and unhygienic conditions. This produces foul smell and breeds various types of insects and infectious organisms besides spoiling the aesthetics of the site.

Industrial solid wastes are sources of toxic metals and hazardous wastes, which may spread on land and can cause changes in physico-chemical and biological characteristics thereby affecting productivity of soils. Toxic substances may leach or percolate to contaminate the ground water.

In refuse mixing, the hazardous wastes are mixed with garbage and other combustible wastes. This makes segregation and disposal all the more difficult and risky. Various types of wastes like cans, pesticides, cleaning solvents, batteries (zinc, lead or mercury), radioactive materials, plastics and e-waste are mixed up with paper, scraps and other non-toxic materials which could be recycled. Burning of some of these materials produces dioxins, furans and polychlorinated biphenyls, which have the potential to cause various types of ailments including cancer.

(C) Management of Solid Waste: For waste management we stress on 'three R's'-Reduce, Reuse and Recycle before destruction and safe storage of wastes.

(*i*) **Reduction in use of raw materials:** Reduction in the use of raw materials will correspondingly decrease the production of waste. Reduced demand for any metallic product will decrease the mining of their metal and cause less production of waste.

(*ii*) **Reuse of waste materials:** The refillable containers which are discarded after use can be reused. Villagers make casseroles and silos from waste paper and other waste materials. Making rubber rings from the discarded cycle tubes which are used by the newspaper vendors, instead of rubber bands, reduces the waste generation during manufacturing of rubber bands. Because of financial constraints poor people reuse their materials to the maximum.

(*iii*) **Recycling of materials:** Recycling is the reprocessing of discarded materials into new useful products.

- Formation of some old type products *e.g.* old aluminium cans and glass bottles are melted and recast into new cans and bottles.
- Formation of new products: Preparation of cellulose insulation from paper, preparation of fuel pellets from kitchen waste. Preparation of automobiles and construction materials from steel cans.

The process of reducing, reusing and recycling saves money, energy, raw materials, land space and also reduces pollution. Recycling of paper will reduce cutting of trees for making fresh paper. Reuse of metals will reduce mining and melting of ores for recovery of metals from ores and prevent pollution.

For **discarding wastes** the following methods can be adopted:

(*i*) **Sanitary landfill:** In a sanitary landfill, garbage is spread out in thin layers, compacted and covered with clay or plastic foam.

In the modern landfills the bottom is covered with an impermeable liner, usually several layers of clay, thick plastic and sand. The liner protects the ground water from being contaminated due to percolation of leachate. Leachate from bottom is pumped and sent for treatment. When landfill is full it is covered with clay, sand, gravel and top soil to prevent seepage of water. Several wells are drilled near the landfill site to monitor if any leakage is contaminating ground water. Methane produced by anaerobic decomposition is collected and burnt to produce electricity or heat.

(*ii*) **Composting:** Due to shortage of space for landfill in bigger cities, the biodegradable yard waste (kept separate from the municipal waste) is allowed to degrade or decompose in an oxygen rich medium. A good quality nutrient rich and environmental friendly manure is formed which improves the soil conditions and fertility.

(*iii*) **Incineration:** Incinerators are burning plants capable of burning a large amount of materials at high temperature generally more than 900°C. The required heat comes from oxidation of organically bound carbon and hydrogen present in the waste material or the added fuel. $C + O_2 \rightarrow CO_2 +$ heat. The initial cost is very high. During incineration high levels of dioxins, furans, lead and cadmium may be emitted with the fly ash of incinerator. Dioxin level may reach many times more than in the ambient environment. For incineration of materials, it is better to remove batteries containing heavy metals and plastic containing chlorine before burning the material. Prior removal of plastics will reduce emissions of dioxins and polychlorinated biphenyls (PCBs).

I. QUESTIONS

1. Define pollution. Name various atmospheric pollutants.
2. What are the natural and man made pollutants that cause air pollution?
3. Give an account of the adverse effects of air pollution.
4. Differentiate between
(*i*) Sound and noise
(*ii*) Loudness and pitch of noise
(*iii*) Threshold of pain and threshold of hearing for a human ear.
5. Briefly describe the sources, effects and control of noise pollution.
6. Give an account of noise generated during diwali. What would you suggest to reduce this menace ?
7. Enumerate with examples the major sources of surface water pollution and ground water pollution.
8. Write short notes on
(*a*) Minamata disease (*b*) Biomagnification
(*c*) Itai-itai disease (*d*) Blue baby syndrome
(*e*) B.O.D.
9. Discuss adverse effects and control of water pollution.
10. What are the major sources of soil pollution ? How does soil pollution affect soil productivity ? What measures can be taken to prevent soil pollution ?
11. Classify solid waste. What are the sources of urban and industrial solid wastes ?
12. What adverse effects can solid wastes cause ? How can the solid waste be managed ?
13. Write short notes on:
(*a*) Donora air pollution episode (*b*) Bhopal gas tragedy
(*c*) Love canal tragedy
(*d*) Chernobyl nuclear disaster.

II. OBJECTIVE TYPE QUESTIONS

(A) FILL IN THE BLANKS

1. ..... forms the highest proportion in the vehicular exhaust.

2. Sulphur dioxide during coal burning is produced due to oxidation of ..... contained in coal.

3. CO has affinity for haemoglobin ..... times more than oxygen.

4. Air pollutants affects plants by entering through ..... .

5. Sound frequency is expressed in ..... .

6. Noise levels considered as threshold of pain are ..... dB.

7. As per Environmental (Protection) (Second Amendment) Rules, 1999 the permissible noise levels for fire-crackers are ..... dB.

8. Minamata disease occurred due to consumption of fish contaminated with .....

9. Blue baby syndrome is caused by the presence of ..... in drinking water.

(B) TRUE OR FALSE

1. Benzo-α-pyrene of cigarette smoke is considered to cause cancer. (True/False)

2. SO_2 does not affect respiratory passage. (True/False)

3. Washing of coal cannot remove sulphur. (True/False)

4. Sound can propagate without any medium. (True/False)

5. Rocket engine causes 90 dB of noise. (True/False)

6. On Diwali the use of fire-crackers is not permitted between 6.00 pm and 10.00 pm. (True/False)

7. Groundwater is not less prone to contamination due to soil mantle. (True/False)

8. Groundwater contamination is irreversible. (True/False)

9. B.O.D. is always higher than C.O.D. (True/False)

10. High temperature increases the dissolved oxygen content in water. (True/False)

11. Solid waste material degraded by micro-organisms are called non-biodegradable. (True/False)

(C) CHOOSE THE CORRECT ANSWER

1. Damage to leaf structure by air pollutants causes

(*a*) Dead areas of leaf (*b*) Chlorophyll reduction

(*c*) Dropping of leaf (*d*) All of these.

2. Air pollutants mixing up with rain can cause

(*a*) High acidity (*b*) Low acidity

(*c*) Neutral conditions (*d*) None of these.

3. Industrial wastes may contain toxic

(*a*) Chemicals (*b*) Phenols

(*c*) Acids (*d*) All of these.

4. Dissolved oxygen in water comes from

(*a*) Photosynthesis of aquatic plants

(*b*) Atmosphere

(*c*) None of these (*d*) Both of these.

5. Itai itai disease in Japan was caused by consumption of rice contaminated with

(*a*) Mercury (*b*) Iron

(*c*) Cadmium (*d*) Zinc.

6. Oil in water affects fish by affecting

(*a*) Gills (*b*) Scales

(*c*) Eyes (*d*) None of these.

7. Which of the following have more penetration power ?

(*a*) Alpha particles (*b*) Beta particles

(*c*) Gamma-rays (*d*) None of these.

8. Bhopal gas tragedy occurred due to leakage of

(*a*) MIC (*b*) DDT

(*c*) SO_2 (*d*) Dioxins.

7

Current Environmental Issues of Importance

Exponential growth of human population, rising standards of living, rapid industrialization, urbanization and addition of a large group of materials in the environment leading to problems like global climate change and acid rain have become important environmental issues in the current times.

7.1 POPULATION GROWTH

In 1800, the earth was home to about 1 billion people. The dramatic way in which global human population grew thereafter is shown in Fig. 7.1. It took about thirty nine thousand years of human history to reach 1 billion, 130 years to reach the second billion, 45 years to reach 4 billion and the next doubling is likely within a span of a few decades. We have already crossed 6 billion and may reach 11 billion by 2045 as per the World Bank estimates.

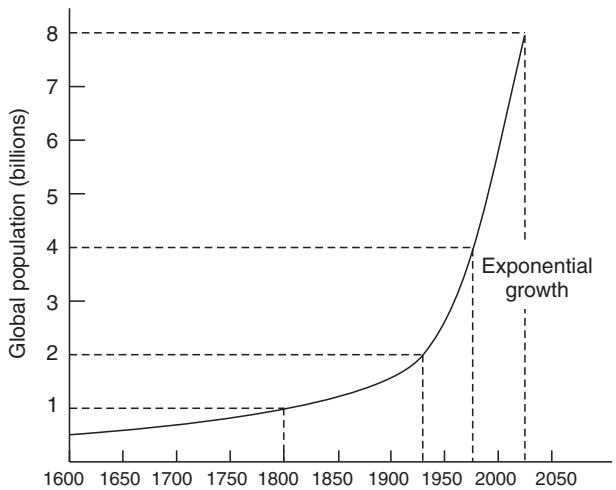


Fig. 7.1. Global population growth trends in the last four centuries.

Let us look at the reasons of this trend of human population growth. In the beginning of human civilization, during the Stone Age, population was quite stable. Environmental conditions were hostile

and humans had not yet developed adequate artificial means for adaptations to these stresses. Droughts and outbreak of diseases used to be quite common leading to mass deaths. The 14th century A.D. experienced large scale mortality due to bubonic plague when about 50% of people in Asia and Europe died due to the disease.

With scientific and technological advancement, life expectancy of humans improved. People started living in definite settlements leading a more stable life with better sanitation, food and medical facilities. Victory over famine-related deaths and infant mortality became instrumental for a rapid increase in population size. In agriculture based societies children were considered as economic assets who would help the parents in the fields and that is why in the developing countries, population growth climbed to unthought-of heights, at the rate of 3–4% per year, accounting for about 90–95% of total population growth of the world in the last 50 years.

(A) Population Characteristics and Variations Among Nations

Exponential growth: When a quantity increases by a constant amount per unit time *e.g.* 1, 3, 5, 7 etc. it is called linear growth. But, when it increases by a fixed percentage it is known as exponential growth *e.g.* 10, 10^2, 10^3, 10^4, or 2, 4, 8, 16, 32 etc. Population growth takes place exponentially and that explains the dramatic increase in global population in the past 150 years.

Doubling time: The time needed for a population to double its size at a constant annual rate is known as doubling time. It is calculated as follows:

Td	=	70/r
where Td	=	Doubling time in years
r	=	annual growth rate

If a nation has 2% annual growth rate, its population will double in 35 years.

Total Fertility Rates (TFR): It is one of the key measures of a nation's population growth. TFR is defined as the average number of children that would be born to a woman in her lifetime if the age-specific birth rates remain constant. The value of TFR varies from 1.9 in developed nations to 4.7 in developing nations. In 1950's the TFR has been 6.1. However, due to changes in cultural and technological set up of societies and government policies the TFR has come down which is a welcome change.

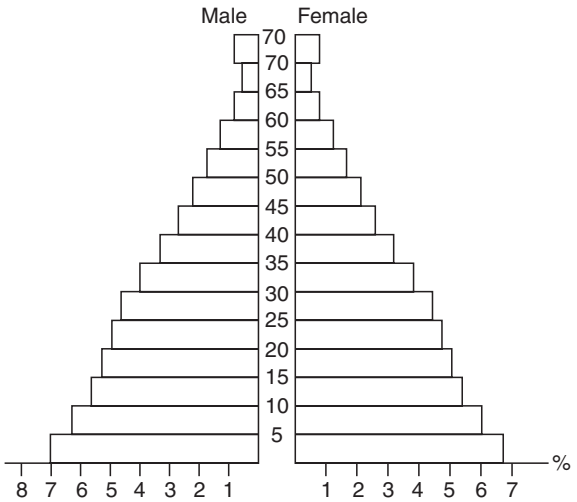
Infant mortality rate: It is an important parameter affecting future growth of a population. It is the percentage of infants died out of those born in a year. Although this rate has declined in the last 50 years, but the pattern differs widely in developed and developing countries.

Replacement level: This is an important concept in population dynamics or demography. Two parents bearing two children will be replaced by their offspring. But, due to infant mortality this replacement level is usually changed. For developing nations, where infant mortality is high and life expectancy is low, the replacement level is approx 2.7, whereas in developed nations it is 2.1.

Age structure: Age structure of population of a nation can be represented by age pyramids, based upon people belonging to different age classes like pre-reproductive (0–14 years), reproductive (15–44 years) and post reproductive (45 years and above). We get three types of age pyramids:

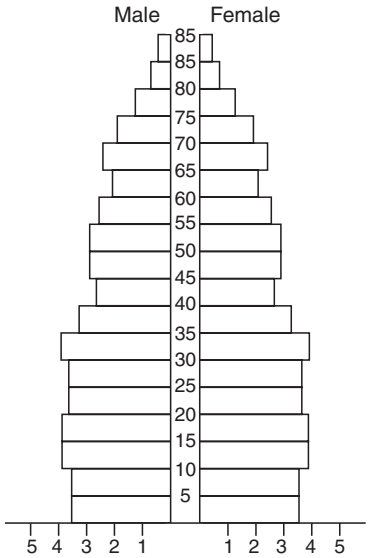
(*a*) **Pyramid shaped:** Here the very young population is more, making a broad base and old people are less. This type indicates growing population. India, Bangladesh, Ethiopia, Nigeria are examples

of this type. The large number of individuals in very young age will soon enter into reproductive age, thus causing an increase in population, whereas less number of people in old age indicate less loss of population due to death (Fig. 7.2(*a*)).



(a) India

(*b*) **Bell shaped:** It occurs in countries like France, USA and Canada where birth rates have in the past one or two decades declined resulting in people of almost equal number in age group 0–35 years. So in the next 10 years, the people entering into reproductive age group is not going to change much and such age-pyramids indicate stable populations (Fig. 7.2(*b*)).



(b) France

(*c*) **Urn shaped:** Here number of individuals in very young class is smaller than the middle reproductive age class. In the next 10 years the number in reproductive age class will thus become less than before resulting in a decline of population growth. Germany, Italy, Hungary, Sweden and Japan are examples of this type (Fig. 7.2(*c*)).

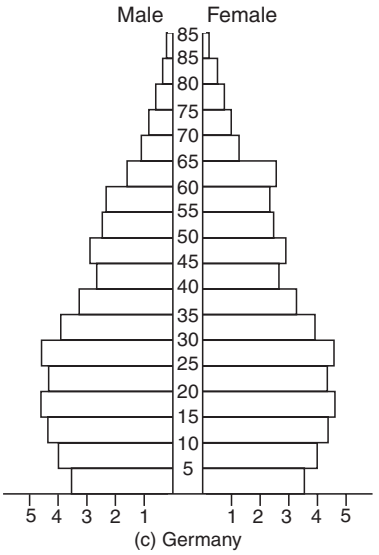


Fig. 7.2. Age pyramids (*a*) Pyramid-shaped expanding population—India, (*b*) Bell-shaped stable population—France, (*c*) Urn-shaped declining population—Germany.

(**Source:** UN Demography Year Book, 2000)

The TFR, age structure, infant mortality and replacement level are all important parameters determining population growth.

Case Studies

- Ethiopia is a developing nation with a pyramid shaped age structure indicating expanding population. Its TFR is 6.9 presently. Even if it aims to reach the replacement level by the year 2050, its population that is 57 million now would rise to 225 million by 2050 when TFR becomes 2.1 and continue growing until it levels off, 100 years later, at 370 million.
- Population growth is also affected due to AIDS in the HIV-prevalent countries mainly in Africa. The earlier population projections of UN are now found to be reduced by 8% in the seriously HIV-affected countries i.e. Mali, Rwanda, Uganda and Zambia. In Zimbabwe, HIV affects a quarter of the population aged between 15–49 yrs. In Botswana, 2/3rd of the 15 year olds are predicted to die of AIDS before reaching 50 years of age. About 30% of adult population in many African countries is HIV-positive. This has drastically reduced life expectancy in these countries.

Zero population growth (ZPG): When birth plus immigration in a population are just equal to deaths plus emigration, it is said to be zero population growth.

Male-female ratio: The ratio of boys and girls should be fairly balanced in a society to flourish. However, due to female infanticides and gender-based abortions, the ratio has been upset in many

countries including India. In China, the ratio of boys to girls became 140 : 100 in many regions which led to scarcity of brides.

Life expectancy: It is the average age that a newborn infant is expected to attain in a given country. The average life expectancy, over the globe, has risen from 40 to 65.5 years over the past century. In India, life expectancy of males and females was only 22.6 years and 23.3 years, respectively in 1900. In the last 100 years improved medical facilities and technological advancement has increased the life expectancy to 60.3 years and 60.5 years, respectively for the Indian males and females. In Japan and Sweden, life expectancy is quite higher, being 82.1–84.2 for females and 77–77.4 for males, respectively.

Demographic transition: Population growth is usually related to economic development. There occurs a typical fall in death rates and birth rates due to improved living conditions leading to low population growth, a phenomenon called demographic transition.

It is associated with urbanisation and growth and occurs in four phases:

(*a*) **Pre-industrial phase** characterized by high growth and death rates and net population growth is low.

(*b*) **Transitional phase** that occurs with the advent of industrialization providing better hygiene and medical facilities and adequate food, thereby reducing deaths. Birth rates, however, remain high and the population shows 2.5–3% growth rate.

(*c*) **Industrial phase** while there is a fall in birth rates thereby lowering growth rate.

(*d*) **Post industrial phase** during which zero population growth is achieved.

Demographic transition is already observed in most developing nations. As a result of demographic transition the developed nations are now growing at a rate of about 0.5% with a doubling time of 118 years. However, the matter of concern is that more than 90% of the global population is concentrated in developing nations which have a growth rate a little more than 2%, and a doubling time of less than 35 years.

(B) Population Explosion: There has been a dramatic reduction in the doubling time of the global human population, as we have already discussed. In the 20th century, human population has grown much faster than ever before. Between 1950–1990, in just 40 years the population crossed 5 billion mark with current addition of about 92 million every year, or so to say, adding a new Mexico every year. In the year 2000, the world population was 6.3 billion and it is predicted to grow four times in the next 100 years. This unprecedented growth of human population at an alarming rate is referred to as **population explosion**.

The Indian Scenario: India is the second most populous country of the world with 1 billion people. If the current growth rates continue, it will have 1.63 billion people by 2050 and will become the most populous country surpassing China. So we are heading for very serious ramifications of the population explosion problem. Do we have the resources and provisions for feeding, housing, educating and employing all those people being added every year? If we look at the population statistics of our country we find that in just 35 years after independence we added another India in terms of population. On 11th May, 2000 we became 1 billion and now we can say that every 6th person in this world is an Indian.

The Population Clock

Every second, on an average 4–5 children are born and 2 people die, thus resulting in net gain of nearly 2.5 person every second. This means that every hour we are growing by about 9000 and everyday by about 2,14,000.

Population explosion is causing severe resource depletion and environmental degradation. Our resources like land, water, fossil fuels, minerals etc. are limited and due to over exploitation these resources are getting exhausted. Even many of the renewable resources like forests, grasslands etc. are under tremendous pressure. Industrial and economic growth are raising our quality of life but adding toxic pollutants into the air, water and soil. As a result, the ecological life-support systems are getting jeopardized. There is a fierce debate on this issue as to whether we should immediately reduce fertility rates through worldwide birth control programs in order to stabilize or even shrink the population or whether human beings will devise new technologies for alternate resources, so that the problem of crossing the carrying capacity of the earth will never actually come.

There are two very important views on population growth which need a mention here:

Malthusian theory: According to Malthus, human populations tend to grow at an exponential or compound rate whereas food production increases very slowly or remains stable. Therefore, starvation, poverty, disease, crime and misery are invariably associated with population explosion. He believes "positive checks" like famines, disease outbreak and violence as well as "preventive checks" like birth control stabilize population growth.

Marxian theory: According to Karl Marx, population growth is a symptom rather than the cause of poverty, resource depletion, pollution and other social ills. He believed that social exploitation and oppression of the less privileged people leads to poverty, overcrowding, unemployment, environmental degradation that in turn, causes over population.

A compromise between the two views is required because all these factors seem to be interdependent and interrelated. Equity and social justice to all, allowing everyone to enjoy a good standard of living is the need of the hour that can voluntarily help in achieving a stabilized global population.

(C) Family Welfare Programmes: Population explosion is like a time bomb that must be diffused well in time. The population must be kept much below the carrying capacity and stabilized, so that the aftermath of explosion could be avoided.

It is not precisely known as to how long can we continue our exponential growth in population and resource use without suffering overshoot or dieback. We are getting warning signals that if not controlled, the increasing population is going to deplete all the resources beyond their regeneration capacity. A catastrophic doomsday model warns us that the earth cannot sustain more than two more doublings *i.e.* 25 billion.

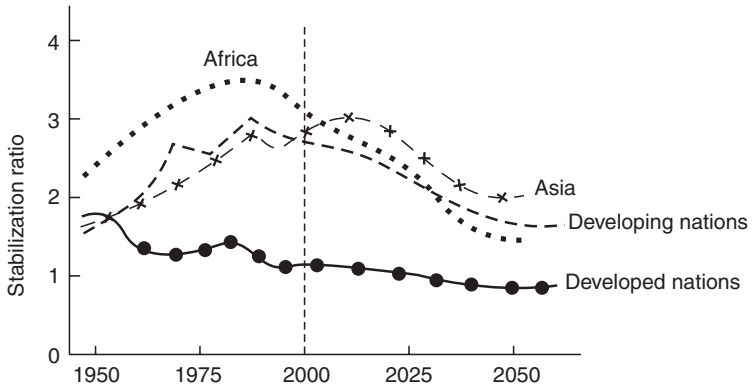


Fig. 7.3. Stabilization ratio of developing & developed nations, Africa and Asia. A ratio of 1 achieved in developed nations around 2000 indicates zero population growth in developed nations while Africa is presently having the highest ratio.

The United Nations projections about **population stabilization** of developed and developing nations and that of Asia are shown in Fig. 7.3. The population stabilization ratio is derived by dividing crude birth rate by crude death rate. As evident, developed nations have already achieved a stabilization ratio of 1 around the year 2000, which is more or less stabilized indicating zero population growth. Developing nations including Asia, on the other hand, is yet having a high stabilization ratio nearing 3, which is however, on a decline and is expected to lower down substantially by 2025. Stabilization in developing nations is possible only through various family welfare programmes.

The Kerala Model (A case study)

Kerala has earned the distinction of having lowest birth rates among all the states of India. The main parameters deciding the effectivity of this model depends upon the age of marriage for women at 21 years, as against and Indian average of 18 years, female literacy of 53% against Indian average of 13%, greater emphasis on primary education with 60% budget provision for the same, as against 50% in many other states, better public distribution system of food among 97% of population, better medical facilities in rural areas and greater success of family planning programmes. The Kerala Model has its own success story emphasizing the effectivity of social justice approach for family planning.

(D) Family Planning: Family planning allows couples to decide their family size and also the time spacing of their offspring. Almost every culture in the past used to practise some traditional fertility control methods through some traditions, taboos and folk medicine.

Modern science has provided several birth control techniques including mechanical barriers, surgical methods, chemical pills and physical barriers to implantation. More than a hundred contraceptive methods are on trial. The **United Nations Family Planning Agency** provides funds to 135 countries. Many of these countries include abortion as a part of the population control programme which very often encourages female infanticide thereby disturbing the optimal male: female ratio in a society. The birth control programmes have often faced strong opposition from religious groups.

Nonetheless, **World Health Organization (WHO)** estimates that today about 50 percent of the worlds' married couples adopt some family planning measures as compared to just 10% about 30 years back. Still some 300 million couples do not have access to family planning.

The Indian Context

India started the family planning programme in 1952 while its population was nearly 400 million. In 1970's, forced family planning campaign by the Government resulted in a turmoil all over the country. In 1978, the government raised the legal minimum age of marriage from 18 to 21 for men and 15 to 18 years for women. Even in 1981 census no drop in population growth was observed. Since then funding for family planning programmes has been increased further.

Unable to reach a consensus regarding population policy, the state governments in 2000 were allowed to adopt their own approach. In Kerala, the population has been stabilized with a focus on social justice as already discussed. It is now comparable to many industrialized nations including USA and it has proved that wealth is not a pre-requisite for zero population growth. Andhra Pradesh has also just achieved the target of ZPG in 2001, but it has been done with a different approach. The poor class was encouraged to be sterilized after two children by paying cash incentives, better land, housing, wells and subsidized loans. In contrast, Bihar and U.P. have showed increase in their growth rates (more than 2.5%).

Successful family planning programme need significant societal changes including social, educational and economic status for women, social security, political stability, proper awareness and confidence building alongwith accessibility and effectivity of the birth control measures.

7.2 CLIMATE CHANGE

Climate is the average weather of an area. It is the general weather conditions, seasonal variations and extremes of weather in a region. Such conditions which average over a long period – at least 30 years – are called climate.

The **Intergovernmental Panel on Climate Change (IPCC)** in 1990 and 1992 published the best available evidence about past climate change, the green house effect and recent changes in global temperature. It is observed that earth's temperature has changed considerably during the geological times. It has experienced several glacial and interglacial periods. However, during the past 10,000 years of the current interglacial period the mean average temperature has fluctuated by 0.5–1°C over 100 to 200 year period. We have relatively stable climate for thousands of years due to which we have practised agriculture and increased in population. Even small changes in climatic conditions may disturb agriculture that would lead to migration of animals including humans.

Anthropogenic (man-made) activities are upsetting the delicate balance that has been established between various components of the environment. Greenhouse gases are increasing in the atmosphere resulting in increase in the average global temperature. This may upset the hydrological cycle, result in floods and droughts in different regions of the world, cause sea level rise, changes in agriculture productivity, famines and death of humans as well as livestock.

The global change in temperature will not be uniform everywhere and will fluctuate in different regions. The places at higher latitudes will be warmed up more during late autumn and winter than the places in tropics. Poles may experience 2 to 3 times more warming than the global average, while warming in the tropics may be only 50 to 100% on an average. The increased warming at poles will reduce the thermal gradient between the equator and high latitude regions decreasing the energy available to the heat engine that drives the global weather machine. This will disturb the global pattern of winds and ocean currents as well as the timing and distribution of rainfall. Shifting of ocean currents may change the climate of Iceland and Britain and may result in cooling at a time when rest of the world warms. By a temperature increase of 1.5 to 4.5°C the global hydrological cycle is expected to intensify by 5 to 10%. Disturbed rainfall will result in some areas becoming wetter and the others drier. Although rainfall may increase, higher temperatures will result in more evapotranspiration leading to annual water deficit in crop fields.

IPCC Report, 2007

The Report of the United Nations Intergovernmental Panel on Climate Change (IPCC), 2007 has been prepared by more than 3000 scientific expert researchers from various countries. The report highlights the unequal availability of water i.e. excess or lack of water leading to increase in droughts and floods. Glaciers in Himalayas will melt and the size and number of glacial lakes will increase. The mid latitude and semi arid regions of the world will experience drier years. Africa will experience water stress. There will be increased availability of water in moist tropics and high latitudes. Rain dependent agricultural produce will get a boost in North America. Sea level and human activities together will contribute to loss of coastal wetlands. Fresh water availability will decrease by 2050. More than a billion people will be at greater risk. The report assesses that 40 per cent species will become extinct. Human health will be affected. There will be increase in number of deaths, diseases like diarrhoea, cardiovascular diseases, etc.
The IPCC headed by Dr. R.K. Pachauri jointly with former US vice-president Al Gore was awarded Nobel Peace Prize for 2007.

7.3 GLOBAL WARMING

Troposphere, the lowermost layer of the atmosphere, traps heat by a natural process due to the presence of certain gases. This effect is called **Greenhouse Effect** as it is similar to the warming effect observed in the horticultural greenhouse made of glass. The amount of heat trapped in the atmosphere depends mostly on the concentrations of "heat trapping" or "greenhouse" gases and the length of time they stay in the atmosphere. The major greenhouse gases are carbon dioxide, ozone, methane, nitrous oxide, chlorofluorocarbons (CFCs) and water vapours. The average global temperature is 15°C. In the absence of greenhouse gases this temperature would have been –18°C. Therefore, Greenhouse Effect contributes a temperature rise to the tune of 33°C. Heat trapped by greenhouse gases in the atmosphere keeps the planet warm enough to allow us and other species to exist. The two predominant greenhouse gases are water vapours, which are controlled by hydrological cycle, and carbon dioxide, which is controlled mostly by the global carbon cycle. While the levels of water vapour in the troposphere have relatively

remained constant, the levels of carbon dioxide have increased. Other gases whose levels have increased due to human activities are methane, nitrous oxide and chlorofluorocarbons. Deforestation has further resulted in elevated levels of carbon dioxide due to non-removal of carbon dioxide by plants through photosynthesis.

Warming or cooling by more than 2°C over the past few decades may prove to be disastrous for various ecosystems on the earth including humans, as it would alter the conditions faster than some species could adapt or migrate. Some areas will become inhabitable because of drought or floods following a rise in average sea level.

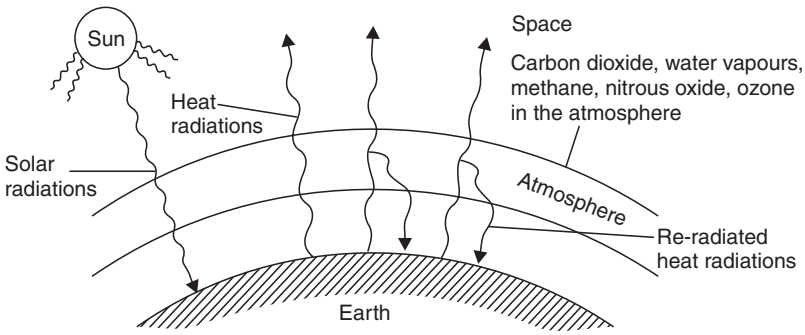


Fig. 7.4. The greenhouse effect.

Greenhouse gases

The phenomenon that worries the environmental scientists is that due to anthropogenic activities there is an increase in the concentration of the greenhouse gases in the air that absorb infrared light containing heat and results in the re-radiation of even more of the outgoing thermal infrared energy, thereby increasing the average surface temperature beyond 15°C. The phenomenon is referred to as the **enhanced greenhouse effect** to distinguish its effect from the one that has been operating naturally for millennia.

The greenhouse gases present in the troposphere and resulting in an increase in the temperature of air and the earth are discussed here:

Carbon dioxide

It contributes about 55% to global warming from greenhouse gases produced by human activity. Industrial countries account for about 76% of annual emissions. The main sources are fossil fuel burning (67%) and deforestation, other forms of land clearing and burning (33%). CO_2 stays in the atmosphere for about 500 years. CO_2 concentration in the atmosphere was 355 ppm in 1990 that is increasing at a rate of 1.5 ppm every year.

Chlorofluorocarbons (CFCs)

These are believed to be responsible for 24% of the human contribution to greenhouse gases. They also deplete ozone in the stratosphere. The main sources of CFCs include leaking air conditioners and refrigerators, evaporation of industrial solvents, production of plastic foams, aerosols, propellants etc. CFCs take 10–15 years to reach the stratosphere and generally trap 1500 to 7000 times more heat per

molecule than CO_2 while they are in the troposphere. This heating effect in the troposphere may be partially offset by the cooling caused when CFCs deplete ozone during their 65 to 110 years stay in the stratosphere. Atmospheric concentration of CFC is 0.00225 ppm that is increasing at a rate of 0.5% annually.

Methane (CH_4)

It accounts for 18% of the increased greenhouse gases. Methane is produced when bacteria break down dead organic matter in moist places that lack oxygen such as swamps, natural wetlands, paddy fields, landfills and digestive tracts of cattle, sheep and termites. Production and use of oil and natural gas and incomplete burning of organic material are also significant sources of methane. Methane stays in the atmosphere for 7–10 years. Each methane molecule traps about 25 times as much heat as a CO_2 molecule. Atmospheric concentration of methane is 1.675 ppm and it is increasing at a rate of 1% annually.

Nitrous Oxide (N_2O)

It is responsible for 6% of the human input of greenhouse gases. Besides trapping heat in the troposphere it also depletes ozone in the stratosphere. It is released from nylon products, from burning of biomass and nitrogen rich fuels (especially coal) and from the break down of nitrogen fertilizers in soil, livestock wastes and nitrate contaminated groundwater. Its life span in the troposphere is 140–190 years and it traps about 230 times as much heat per molecule as CO_2. The atmospheric concentration of N_2O is 0.3 ppm and is increasing at a rate of 0.2% annually.

Impacts of Enhanced Greenhouse Effect

The enhanced greenhouse effect will not only cause global warming but will also affect various other climatic and natural processes.

(*i*) **Global temperature increase:** It is estimated that the earth's mean temperature will rise between 1.5 to 5.5°C by 2050 if input of greenhouse gases continues to rise at the present rate. Even at the lower value, earth would be warmer than it has been for 10,000 years.

(*ii*) **Rise in sea level:** With the increase in global temperature sea water will expand. Heating will melt the polar ice sheets and glaciers resulting in further rise in sea level. Current models indicate that an increase in the average atmospheric temperature of 3°C would raise the average global sea level by 0.2–1.5 meters over the next 50–100 years.

One meter rise in sea level will inundate low lying areas of cities like Shanghai, Cairo, Bangkok, Sydney, Hamburg and Venice as well as agricultural lowlands and deltas in Egypt, Bangladesh, India, China and will affect rice productivity. This will also disturb many commercially important spawning grounds, and would probably increase the frequency of storm damage to lagoons, estuaries and coral reefs.

In India, the Lakshadweep Islands with a maximum height of 4 meters above the sea level may be vulnerable. Some of the most beautiful cities like Mumbai may be saved by heavy investment on embankment to prevent inundation.

Life of millions of people will be affected by the sea level rise who have built homes in the deltas of the Ganges, the Nile, the Mekong, the Yangtze and the Mississippi rivers.

(*iii*) **Effects on human health:** The global warming will lead to changes in the rainfall pattern in many areas, thereby affecting the distribution of vector-borne diseases like malaria, filariasis, elephantiasis etc.

Areas which are presently free from diseases like malaria, schistosomiasis etc. may become the breeding grounds for the vectors of such diseases. The areas likely to be affected in this manner are Ethiopia, Kenya and Indonesia. Warmer temperature and more water stagnation would favour the breeding of mosquitoes, snails and some insects, which are the vectors of such diseases.

Higher temperature and humidity will increase/aggravate respiratory and skin diseases.

(*iv*) **Effects on agriculture:** There are different views regarding the effect of global warming on agriculture. It may show positive or negative effects on various types of crops in different regions of the world. Tropical and subtropical regions will be more affected since the average temperature in these regions is already on the higher side. Even a rise of 2°C may be quite harmful to crops. Soil moisture will decrease and evapotranspiration will increase, which may drastically affect wheat and maize production.

Increase in temperature and humidity will increase pest growth like the growth of vectors for various diseases. Pests will adapt to such changes better than the crops.

To cope up with the changing situation, drought resistant, heat resistant and pest resistant varieties of crops have to be developed.

Measures to Check Global Warming

To slow down enhanced global warming the following steps will be important:

(*i*) Cut down the current rate of use of CFCs and fossil fuel.
(*ii*) Use energy more efficiently.
(*iii*) Shift to renewable energy resources.
(*iv*) Increase nuclear power plants for electricity production.
(*v*) Shift from coal to natural gas.
(*vi*) Trap and use methane as a fuel.
(*vii*) Reduce beef production.
(*viii*) Adopt sustainable agriculture.
(*ix*) Stabilize population growth.
(*x*) Efficiently remove CO_2 from smoke stacks.
(*xi*) Plant more trees.
(*xii*) Remove atmospheric CO_2 by utilizing photosynthetic algae.

7.4 ACID RAIN

Oxides of sulfur and nitrogen originating from industrial operations and fossil fuel combustion are the major sources of acid forming gases. Acid forming gases are oxidised over several days by which time they travel several thousand kilometers. In the atmosphere these gases are ultimately converted into

sulfuric and nitric acids. Hydrogen chloride emission forms hydrochloric acid. These acids cause acidic rain. Acid rain is only one component of acidic deposition. Acidic deposition is the total of wet acidic deposition (acid rain) and dry deposition.

Rain water is turned acidic when its pH falls below 5.6 (Fig. 7.5). In fact clean or natural rain water has a pH of 5.6 at 20°C because of formation of carbonic acid due to dissolution of CO_2 in water.

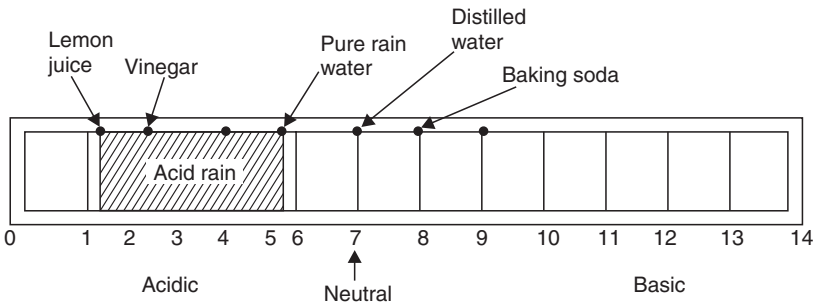


Fig. 7.5. The pH scale of common substances.

The Adirondack Lakes located in the state of New York are known to receive acid rains.

The strong acids like sulphuric acid (H_2SO_4) and nitric acid (HNO_3) dissolved or formed in rainwater dissociate or release hydrogen ions thereby increasing the acidity in rain drops.

Generally sulfuric acid forms a major fraction of acid rain, followed by nitric acid and a very small fraction of other acids. However, in urban areas calcium (Ca^{2+}), magnesium (Mg^{2+}) and ammonium (NH^{4+}) ions help to neutralize the rain drops shifting the overall H^+ towards basic scale. The overall pH of any raindrop is due to the net effect of carbonic acid, sulfuric acid, nitric acid and other acidic constituents or any neutralizers such as ammonia.

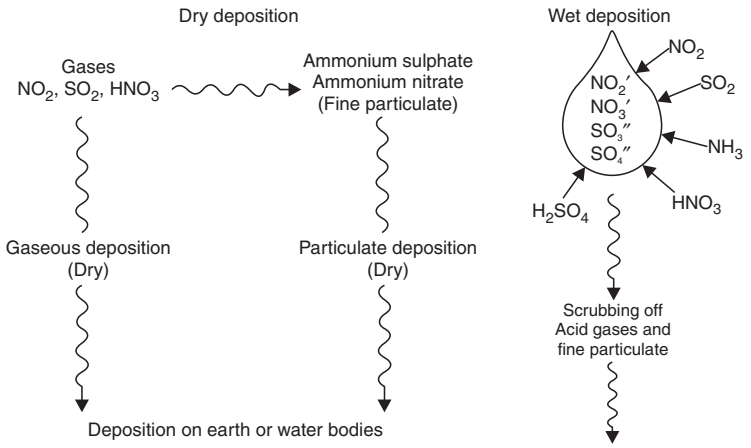


Fig. 7.6. Acid deposition (dry deposition and wet deposition).

In the absence of rain, dry deposition of acid may occur. Acid forming gases like oxides of sulphur and nitrogen and acid aerosols get deposited on the surface of water bodies, vegetation, soil and other materials. On moist surfaces or in liquids these acid forming gases can dissolve and form acids

similar to that formed in acid rain. If the oxidizers are present on the liquid surfaces then these gases undergo oxidation to form acids. Fine particles or acid droplets can act as nuclei for water to condense to form rain droplets. By such process sulfuric acid is incorporated into the droplets. In the clouds additional SO_2 and NO_2 contact the droplets and get absorbed which can be oxidized by the dissolved hydrogen peroxide (H_2O_2) or other oxidizers. In the droplets falling from the clouds additional acidic gases and aerosol particles get incorporated, further decreasing their pH. A unit decrease in pH value causes 10 times increase in acidity. Average pH in rainfall over eastern United States from April 1979 to March 1980 was less than 5.0. In India acid rain is recorded from certain places:

Name of place	pH of rainwater
Kodaikanal	5.18
Minicoy	5.52
Mohanbari	5.50

Effects of Acid Rain

Acid rain causes a number of harmful effects below pH 5.1. The effects are visible in the aquatic system even at pH less than 5.5.

- It causes deterioration of buildings especially made of marble *e.g.* monuments like Taj Mahal. Crystals of calcium and magnesium sulphate are formed as a result of corrosion caused by acid rain.
- It damages stone statues. Priceless stone statues in Greece and Italy have been partially dissolved by acid rain.
- It damages metals and car finishes.
- Aquatic life especially fish are badly affected by lake acidification.
- Aquatic animals suffer from toxicity of metals such as aluminium, mercury, manganese, zinc and lead which leak from the surrounding rocks due to acid rain.
- It results in reproductive failure and killing of fish.
- Many lakes of Sweden, Norway, Canada have become fishless due to acid rain.
- It damages foliage and weakens trees.
- It makes trees more susceptible to stresses like cold temperature, drought, etc. Many insects and fungi are more tolerant to acidic conditions and hence they can attack the susceptible trees and cause diseases.

Control of Acid Rain

- Emission of SO_2 and NO_2 from industries and power plants should be reduced by using pollution control equipments.
- Liming of lakes and soils should be done to correct the adverse effects of acid rain.
- A coating of protective layer of inert polymer should be given in the interior of water pipes for drinking water.

7.5 OZONE LAYER DEPLETION

For the last 450 million years the earth has had a natural sunscreen in the stratosphere called the ozone layer. This layer filters out harmful ultraviolet radiations from the sunlight and thus protects various life forms on the earth.

Ozone is a form of oxygen. The molecule of oxygen contains two atoms whereas that of ozone contains three (O_3). In the stratosphere ozone is continuously being created by the absorption of short wavelength ultraviolet (UV) radiations. Ultraviolet radiations less than 242 nanometers decompose molecular oxygen into atomic oxygen (O) by photolytic decomposition.

$$O_2 + h\nu \longrightarrow O + O$$

The atomic oxygen rapidly reacts with molecular oxygen to form ozone.

$$O + O_2 + M \longrightarrow O_3 + M$$

(M is a third body necessary to carry away the energy released in the reaction).

Ozone thus formed distributes itself in the stratosphere and absorbs harmful ultraviolet radiations (200 to 320 nm) and is continuously being converted back to molecular oxygen.

$$O_3 + h\nu \longrightarrow O_2 + O$$

Absorption of UV radiations results in heating of the stratosphere.

The net result of the above reactions is an equilibrium concentration of ozone. Ozone concentration in about 24 km of the stratosphere *i.e.* from 16 km to 40 km away from earth is about 10 ppm (as compared to 0.05 ppm concentration of harmful tropospheric ozone). This equilibrium is disturbed by reactive atoms of chlorine, bromine etc. which destroy ozone molecules and result is thinning of ozone layer generally called ozone hole.

The amount of atmospheric ozone is measured by 'Dobson Spectrometer' and is expressed in **Dobson units (DU)**. One DU is equivalent to a 0.01 mm thickness of pure ozone at the density it would possess if it were brought to ground level (1atm) pressure. Normally over temperate latitude its concetration is about 350 DU, over tropics it is 250 DU whereas at subpolar regions (except when ozone thinning occurs) it is on an average 450 DU. It is because of the stratospheric winds which transport ozone from tropical towards polar regions.

Thinning of Ozone Layer

The Antarctic ozone hole was discovered by Dr. Joe C. Farman and his colleagues in the British Antarctic Survey who had been recording ozone levels over this region since 1957. During spring season of south pole *i.e.* September to November each year ozone depletion is observed. Steep decline has been observed since mid 1970s with a record low concentration of 90 DU in early October of 1993.

Chlorofluorocarbons (CFCs) are mainly responsible for ozone depletion in the stratosphere. CFCs are a group of synthetic chemicals first discovered by Thomas Midgley Jr. in 1930. CFC-11 and CFC-12 are the CFCs most commonly used. CFCs are used as coolants in refrigerators and air conditioners, as propellants, cleaning solvents, sterilant and in styrofoam etc. CFCs released in the troposphere reach the stratosphere and remain there for 65–110 years destroying O_3 molecules. In 1974, Rowland and Molina warned that CFCs are lowering the concentration of ozone in the stratosphere and

predicted severe consequences. It was however, in 1985 that scientists for the first time discovered that 50% (98% in some areas) of upper stratospheric ozone over Antarctica was destroyed during the Antarctic spring and early summer (September-December). At Antarctic region the temperature during winter drops to – 90°C. The winds blowing in a circular pattern over earth's poles create polar vortices. Water droplets in clouds when they enter these vortices form ice crystals. CFCs get collected on the surfaces of these ice crystals and destroy ozone much faster. Similar destruction of ozone over North Pole occurs during Arctic spring and early summer (February-June). The depletion is 10–25% and it is less than that observed at south pole.

Nitrous oxide emitted by supersonic aircrafts during combustion of fossil fuel, and use of nitrogen fertilizers breaks ozone molecules. Chlorine liberated from chlorofluorocarbons also break ozone molecules. The chain reaction started in Antarctic spring *i.e.* August/September continues till nitrogen dioxide is liberated from nitric acid formed in the stratosphere by photolysis (breakdown by sunlight). Nitrogen dioxide combines with chlorine and stops further destruction of ozone.

Effects of Ozone Depletion

- Ozone depletion in the stratosphere will result in more UV radiation reaching the earth especially UV-B (290–320 nm). The UV-B radiations affect DNA and the photosynthetic chemicals. Any change in DNA can result in mutation and cancer. Cases of skin cancer (basal and squamous cell carcinoma) which do not cause death but cause disfigurement will increase.
- Easy absorption of UV rays by the lens and cornea of eye will result in increase in incidents of cataract.
- Melanin producing cells of the epidermis (important for human immune system) will be destroyed by UV-rays resulting in immuno-suppression. Fair people (who cannot produce enough melanin) will be at a greater risk of UV exposure.
- Phytoplanktons are sensitive to UV exposure. Ozone depletion will result in decrease in their population thereby affecting the population of zooplankton, fish, marine animals, in fact the whole aquatic food chain.
- Yield of vital crops like corn, rice, soybean, cotton, bean, pea, sorghum and wheat will decrease.
- Degradation of paints, plastics and other polymer material will result in economic loss due to effects of UV radiation resulting from ozone depletion.

7.6 URBANIZATION

An urban area is defined as a town or city along with its adjacent suburban fringes with a population exceeding 2500 (as per U.S. Bureau of Census). However, this value is set at a minimum of 10,000 – 50,000 in different countries. But in Denmark a population of 250 makes an area urban.

Urbanization is the growth of urban population by natural growth or immigration from rural areas. Rural population moves to urban areas to find employment there, because of poverty, declining agricultural jobs and inadequate and uneconomical market valuation of crops.

7.6.1 Characteristics and Patterns of Urban Population

(*i*) These are heterogenous populations with much greater diversity of race, religion, ethnicity, socio-economic status and nationality as compared to rural population.

(*ii*) In developing countries urban areas have more males, who migrate in search of job from rural areas. While in developed countries the women from rural areas migrate more to cities to seek employment.

(*iii*) Urban population is growing very fast. Between 1850 and 2003, global urban population increased from a mere 2% to 47%, which will be 63% in 2050, as per UN (United Nations) projections.

(*iv*) In 1900, there were only 19 cities having more than 1 million population and in 2003 the number of such cities increased to 400. These are called large cities.

Megacities, which have a population size exceeding 10 million have also increased in number from 8 in the year 1985 to 19 in the year 2003.

(*v*) Urban growth is much faster in developing countries than in developed ones.

(*vi*) Poverty is a main cause of urbanization, when poor people from villages move to urban areas and get crowded in slums with most unhygienic conditions.

7.6.2 Environment Related Urban Problems and Benefits

(*i*) Urban areas suffer from serious problems of environmental pollution. There are high levels of air pollution and noise pollution due to industries and automobiles. Water is also polluted due to industrial wastewater discharge. Solid waste generation in urban areas is very high, and its proper disposal is a major problem.

(*ii*) Proper sewerage facilities are often lacking in urban areas. In the crowded slums, the human waste is just deposited in gutters or vacant spaces, which become a breeding ground for pathogenic bacteria spreading salmonella and hepatitis infections.

In most of the cities heavy rainfall totally upsets the sewerage system.

(*iii*) Cities are warmer than villages. Due to lot of heat released by various types of human activities in cities, which get retained by built structures and then slowly released into the atmosphere there is creation of **urban heat island**. This problem can be partially tackled by growing green belts of trees.

(*iv*) Urbanization also provides several benefits when there is a well-planned city with proper transportation and residential facilities, reducing pollution problems.

(*v*) Due to better access to health care, educational and social service facilities, infant mortality is less in cities.

7.7 AUTOMOBILE POLLUTION

Development of internal combustion engine (gasoline engine) in the late 1800s revolutionised modes of transportation. It was in 1900s that road transport progressed rapidly. In the last few decades the number of personal vehicles increased amazingly due to convenience, safety and affordability. This has come with a cost to the environment.

People specially in the urban areas are exposed to vehicular exhaust. The most vulnerable group is the traffic policemen. Pollutants from automobiles are emitted to the atmosphere through exhaust pipe (70%), crank case (20%) and by evaporation from fuel tank and carburettor (10%). The following pollutants are emitted from the vehicular exhaust. carbon monoxide (CO), unburnt hydrocarbons, oxides of nitrogen (NO_x), oxides of sulphur (SO_x), particulate matter, smoke and odour. The petrol engine exhaust contains carbon monoxide, unburnt hydrocarbons, nitrogen oxides and particular matter. It is almost colourless. The diesel engine exhaust contains unburnt hydrocarbons, nitrogen oxides, sulphur oxides, particulate matter, smoke and odour. This exhaust is dirty and generally blue or black.

Emission of carbon monoxide and hydrocarbons is high during idling and deceleration and low during acceleration and high speed while levels of NO_x are high during acceleration and high speed and low during idling, deceleration and low speed. Levels of these pollutants are minimum at the recommended inform speed. Millions of vehicles spew into the atmosphere hundreds of metric tonnes of pollutants per day. Carbon monoxide contributes about 70% of the vehicular exhaust.

Effects of vehicular pollution: The ill effects of air pollutants have been discussed in the air pollution chapter. Vehicular pollution may produce from minor effects to serious illness sometimes leading to premature deaths. Vehicular pollution produces and aggravates respiratory and cardiovascular diseases. In the metros the situation is of special concern as thousands of people die prematurely due to this type of pollution. The worst affected cities are Delhi, Kolkata, Agra, Ahmedabad, Jaipur, Kanpur, Nagpur, Mumbai, Chennai etc. The pollution problems are aggravated in the cities where alongwith SO_2, the particulate (suspended particulate matter) concentration is also high. This increases morbidity and mortality due to their synergistic (enhancing each others toxicity) effects.

Besides affecting human health, vehicular pollution affects environment also. Vehicular pollutants produce photochemical smog in the presence of sunlight. Los Angeles has a large number of vehicles and abundant sunshine and experiences frequent incidents of photochemical smog. For this reason it is called the pollution capital of the world. Vehicular pollution contributes to the major green house gas CO_2 which contributes to climate change (global warming). Vehicles are responsible for one-third of worlds total oil consumption resulting in depletion of this resource at a faster rate. Vehicular pollution seriously affects the living beings and crops especially when pollutants get trapped under inversion layer in winter months.

Control measures: Vehicular pollution can be minimized or controlled by adopting some of the following measures:

- Use of alternate fuel which generates less pollutants on combustion.
- Ensure complete combustion of fuel which changes pollutants into less harmful products.
- Use of catalytic converters.
- Modification of internal combustion engine for improvement of its efficiency.
- Replacement of internal Combustion engine with the engine which produces less pollutants.

7.8 ANIMAL HUSBANDRY

Animal husbandry or livestock raising is an important aspect of environment. It provides us food resources rich in protein. Sheep, pigs, chicken, turkeys, geese, ducks, cows, buffaloes and goats are some of the

important types of livestock. They provide us milk, eggs, meat and milk products. Besides this fish, crabs, prawns, shrimps, shellfish etc. also provide us protein rich food resources and are nowadays grown in aquaculture.

Some of the important environmental aspects associated with animal husbandry are discussed here:

(*i*) Domestication of animals leads to loss of *genetic diversity*. This is because animals with the most desirable traits are selected, which have value to humans. Other traits, which may be useful otherwise are not selected. This leads to uniform type of characters in the livestock population. If there is a disease outbreak in a uniform population, the whole population is susceptible and the loss is much greater as compared to a natural population, where some individuals would have genes to resist the pathogens due to genetic diversity.

(*ii*) The livestock have to be grazed on grassland or pastures. Very often the livestock grazing on a particular piece of grassland surpass its carrying capacity. *Carrying capacity* of any system is the maximum population that can be supported by it on a sustainable basis. When the grazing pressure is high, it leads to several problems like land degradation, soil erosion and loss of useful species.

Overgrazing removes the vegetation cover and exposes the soil to the action of strong wind and rainfall leading to soil erosion. Also, due to decline in litter, the organic matter and humus content of the soil decline leading to organically poor, dry, compacted soil. Overgrazing adversely affects the root stocks of good quality plants, which can no longer regenerate. Their position is gradually taken up by unpalatable, thorny plants, which are poor soil binders. Thus, there is overall degradation of land due to overgrazing.

(*iii*) For increasing livestock yields, use of hormones and antibiotics has come up, but the use of both is controversial, due to serious health concern for human consumers. Presence of implanted hormones in livestock products have been found to be very harmful to humans. Indiscriminate use of antibiotics in livestock results in evolution of such bacteria that have greater resistance to antibiotics, thus posing greater risks to us.

(*iv*) Animal wastes are rich in nitrogen and also phosphorus. If these wastes are not properly handed and managed these enter into water bodies with run-off, leading to over-nourishment or eutrophication of the same. The phenomenon has already been explained in an earlier chapter while dealing with effects of agriculture. Eutrophication leads to disastrous degradation of a water body in a short time.

(*v*) Animal wastes of certain livestock animals can serve as manure for increasing the productivity of croplands. They form an important component of organic farming.

(*vi*) Livestock are also a big contributor to emission of methane in the atmosphere. Food in the stomach of ruminants is acted upon by anaerobic bacteria and methane is produced. Methane comes to the atmosphere with their belch. Methane is 25 times more potent green house gas than CO_2 and contributes to climate change (global warming).

I. QUESTIONS

1. What do you mean by (*a*) Doubling time (*b*) total fertility rate (*c*) zero population growth (*d*) Life expectancy?
2. How can age-structure pyramids serve as useful tools for predicting population growth trends of a nation? Explain with examples.
3. What is meant by 'Population Explosion'? Discuss the Indian scenario.
4. What is meant by population stabilization? Discuss the family welfare and family planning program in Indian context.
5. Discuss the influence of environmental parameters and pollution on human health.
6. What are greenhouse gases and greenhouse effect ? Discuss the potential and contribution of these gases to global warming phenomenon.
7. What are the major implications of enhanced global warming?

   What is meant by acid rain? How does it form? In which regions of India acid rain has been recorded?
8. What are the major impacts of acid rain and how can we control it?
9. Discuss the natural formation and occurrence of ozone in the stratosphere.
10. Which are the agents responsible for ozone depletion?
11. Discuss environment related problems and benefits.
12. Describe the effects of vehicular pollution on man and environment.
13. Discuss various environmental aspects associated with animal husbandry.

(A) FILL IN THE BLANKS

1. When a population increases by a fixed percentage it is called ..... growth.
2. When birth plus immigration in a population are just equal to deaths plus emigration, it is known as ..... .
3. The phenomenon of fall in death rates and birth rates due to improved living conditions leading to low population growth is called ..... .
4. The average global temperature is 15°C. In the absence of greenhouse gases the temperature would have been ..... .
5. In acid rain, the pH of rain water falls below ..... .
6. The atmospheric emissions of NO_2 and ..... cause acid rain.
7. Ozone layer acts as a natural sunscreen which protects life on this earth against ..... rays.
8. Ozone depleting nature of CFC's was first reported by ..... and .....
9. Cities are warmer than villages due to ..... .
10. CO contributes about ..... % of vehicular exhaust.
11. Livestock contributes ..... which is a greenhouse gas.

(B) CHOOSE THE CORRECT ANSWER

1. The world famous report on ''The Limits to Growth'' predicting that the world will meet the doom's day, if growth continues limitlessly, was written by

(*a*) Myers *et al.* (*b*) Meadows *et al*.

(*c*) Brundtland (*d*) Wilson *et al.*

2. The present world population has just crossed

(*a*) 4 billion (*b*) 5 billion

(*c*) 6 billion (*d*) 8 billion.

3. If a nation has an annual growth rate of 2%, its population will double in

(*a*) 20 years (*b*) 35 years

(*c*) 50 years (*d*) 70 years.

4. Expanding population trend is predicted for the coming years when age-pyramid is

(*a*) Bell-shaped (*b*) Pyramid shaped

(*c*) Urn-shaped (*d*) None of these.

5. Every ..... person in this world is an Indian.

(*a*) Fifth (*b*) Sixth

(*c*) Seventh (*d*) Tenth.

6. Which state in India has the lowest birth rate?

(*a*) Kerala (*b*) Bihar

(*c*) Jammu and Kashmir (*d*) Himachal Pradesh.

7. Which of the following gases has maximum contribution to enhanced greenhouse effect ?

(*a*) CFC's (*b*) CH_4

(*c*) CO_2 (*d*) N_2O.

8. Cattle, sheep and termites are responsible for the release of the following greenhouse gas

(*a*) Methane (*b*) Carbon dioxide

(*c*) Nitrous oxide (*d*) All of these.

9. The most important agents for ozone depletion are

(*a*) Methane (*b*) CFC's

(*c*) Nuclear fallout (*d*) Nitrous oxide.

10. Maximum depletion of ozone occurs on

(*a*) Equator (*b*) North pole

(*c*) South pole (*d*) Tropics.

11. Vehicular pollution has maximum effects on

(*a*) Respiratory system (*b*) Brain

(*c*) Kidney (*d*) Liver.

12. In the stomach of numinant which of the following bacteria produce methane?

(*a*) Aerobic bacteria (*b*) Anaerobic bacteria

(*c*) None of these (*d*) Both of these.

(C) WRITE TRUE OR FALSE

1. Need for more man-power in agriculture-based societies has been responsible for an exceptionally high population growth in developing countries. (True/False)

2. Total fertility rate and infant mortality rates are lower in developing countries. (True/False)

3. Life expectancy over the globe has improved over the past century. (True/False)

4. Green house effect is good while enhanced green house effect is bad. (True/False)

5. pH of normal rain is 5.6. (True/False)

6. Due to ozone depletion there will be increased incidence of skin cancer and eye cataract. (True/False)

7. Diesel engine exhause contains sulphur oxides. (True/False)

8. Overgrazing can lead to soil erosion. (True/False)

8

Environmental Protection

The major environmental issues that have become a cause of concern are population growth, rapid and wasteful use of resources, loss of biodiversity and degradation of ecosystems, pollution of the water, air and soil, poverty, disparity in economic growth, global climate change, energy crisis and unsustainable growth trends. In order to protect the environment efforts have to be done at individual level as well as national and international level. The role of government and non-government organizations (NGOs) are equally important. Legislative measures are also very important in ensuring environmental protection. Environmental awareness, education and particularly, women education hold a significant place in promoting the spirit of environmental protection.

8.1 ROLE OF GOVERNMENT

Environmental protection can be done by formulating some guidelines, policies and laws by the government.

India is the first country in the world to have made provisions for the protection and conservation of environment in its Constitution. On 5th June, 1972, environment was first discussed as an item of international agenda in the **U.N. Conference on Human Environment** in Stockholm and thereafter **5th June** is celebrated all over the world as **World Environment Day**. Soon after the Stockholm Conference our country took substantive legislative steps for environmental protection. The Wildlife (Protection) Act was passed in 1972, followed by the Water (Prevention and Control of Pollution) Act 1974, the Forest (Conservation) Act, 1980, Air (Prevention and Control of Pollution) Act, 1981 and subsequently the Environment (Protection) Act, 1986.

Constitutional Provisions

Provisions for environmental protection in the Constitution of India were made within four years of Stockholm Conference, in 1976, through the 42nd amendment as follows:

Article 48-A of the Constitution provides: *"The state shall endeavour to protect and improve the environment and to safeguard forests and wildlife of the country."*

Article 51A(g) provides: *"It shall be the duty of every citizen of India to protect and improve the natural environment including forests, lakes, rivers and wildlife and to have compassion for living creatures."*

Thus our Constitution includes environmental protection and conservation as one of our fundamental duties.

Some of the important Acts passed by the Government of India are discussed here. These Acts have the force of law and these environment laws are powerful tools for implementing environmental protection.

8.2 LEGAL ASPECTS

8.2.1 Wildlife (Protection) Act, 1972

The Act, a landmark in the history of wildlife legislation in our country, came into existence in 1972. Wildlife was transferred from State List to Concurrent List in 1976, thus giving power to the Central government to enact the legislation.

The **Indian Board of Wildlife (IBWL)** was created in 1952 in our country, which after the enactment of the Wildlife (Protection) Act actively took up the task of setting up wildlife national parks and sanctuaries. The major activities and provisions in the Act can be summed up as follows:

(*i*) It defines the wildlife related terminology.

(*ii*) It provides for the appointment of Wildlife Advisory Board, wildlife warden, their powers, duties etc.

(*iii*) Under the Act, comprehensive listing of endangered wildlife species was done for the first time and prohibition of hunting of the endangered species was mentioned.

(*iv*) Protection to some endangered plants like Beddome cycad, Blue vanda, Ladies slipper orchid, Pitcher plant etc. is also provided under the Act.

(*v*) The Act provides for setting up of national parks, wildlife sanctuaries etc.

(*vi*) The Act provides for the constitution of Central Zoo Authority.

(*vii*) There is provision for trade and commerce in some wildlife species with license for sale, possession, transfer etc.

(*viii*) The Act imposes a ban on the trade or commerce in scheduled animals (Fig. 8.1).

(*ix*) It provides for legal powers to officers and punishment to offenders.

(*x*) It provides for captive breeding programme for endangered species.

Several conservation projects for individual endangered species like lion (1972), tiger (1973), crocodile (1974) and brown antlered deer (1981) were started under this Act. The Act is adopted by all states in India except J & K, which has it own Act.

Some of the major drawbacks of the Act include mild penalty to offenders, illegal wildlife trade in J & K, personal ownership certificate for animal articles like tiger and leopard skins, no coverage of foreign endangered wildlife, pitiable condition of wildlife in mobile zoos and little emphasis on protection of plant genetic resources.

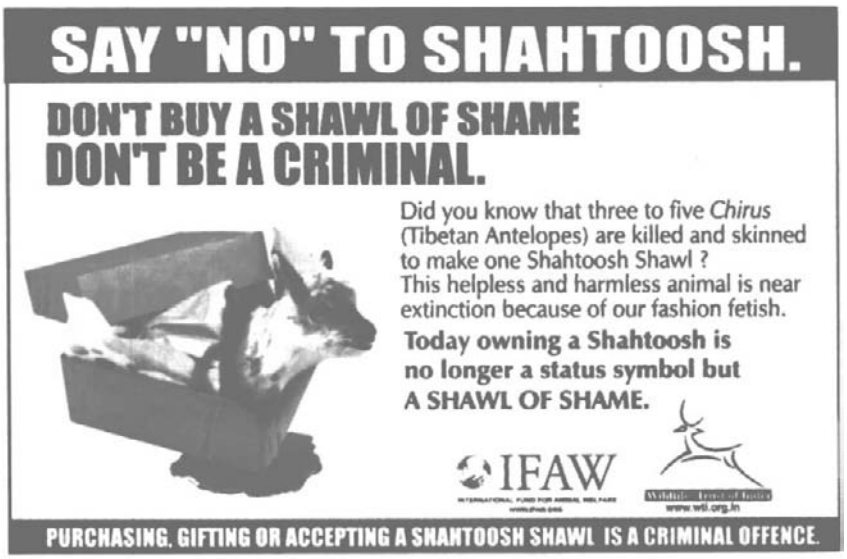

SAY "NO" TO SHAHTOOSH.
DON'T BUY A SHAWL OF SHAME
DON'T BE A CRIMINAL.
Did you know that three to five Chirus (Tibetan Antelopes) are killed and skinned to make one Shahtoosh Shawl ?
This helpless and harmless animal is near extinction because of our fashion fetish.
Today owning a Shahtoosh is no longer a status symbol but A SHAWL OF SHAME.
IFAW
www.wti.org.in
PURCHASING, GIFTING OR ACCEPTING A SHAHTOOSH SHAWL IS A CRIMINAL OFFENCE.

Fig. 8.1. A newspaper clipping advocating illegality of trading in scheduled animals and products.

8.2.2 Forest (Conservation) Act, 1980

This Act deals with the conservation of forests and related aspects. Except J & K, the Act is adopted all over India. The Act covers under it all types of forests including reserve forests, protected forests or any forested land irrespective of its ownership.

The salient features of the Act are as follows:

(*i*) The State government has been empowered under this Act to use the forests only for forestry purposes. If at all it wants to use it in any other way, it has to take prior approval of Central government, after which it can pass orders for declaring some part of the reserve forest for non-forest purposes (*e.g.* mining) or for clearing some naturally growing trees and replacing them by economically important trees (reforestation).

(*ii*) It makes provision for conservation of all types of forests and for this purpose there is an advisory committee which recommends funding for it to the Central government.

(*iii*) Any illegal non-forest activity within a forest area can be immediately stopped under this Act.

Non-forest activities include clearing of forest land for cultivation of any type of plants/crops or any other purpose (except re-afforestation). However, some construction work in the forest for wildlife or forest management is exempted from non-forest activity (*e.g.* fencing, making water-holes, trench, pipelines, check posts, wireless communication etc.).

1992 Amendment in the Forest Act

- In 1992, some amendments was made in the Act which made provisions for allowing some non-forest activities in forests, without cutting trees or limited cutting with prior approval of Central government. These activities are setting of transmission lines, seismic surveys, exploration, drilling and hydroelectric projects. The last activity involves large scale destruction of forests, for which prior approval of the Centre is necessary.
- Wildlife sanctuaries, national parks etc. are totally prohibited for any exploration or survey under this Act without prior approval of Central govt. even if no tree-felling is involved.

- Cultivation of tea, coffee, spices, rubber and plants which are cash-crops, are included under non-forestry activity and not allowed in reserve forests.
- Even cultivation of fruit-bearing trees, oil-yielding plants or plants of medicinal value in forest area need to be first approved by the Central govt. This is because newly introduced species in the forest area may cause an imbalance in the ecology of the forest. If the species to be planted is a native species, then no prior clearance is required.
- Tusser cultivation (a type of silk-yielding insect) in forest areas by tribals as a means of their livelihood is treated as a forestry activity as long as it does not involve some specific host tree like Asan or Arjun. This is done in order to discourage monoculture practices in the forests which are otherwise rich in biodiversity.
- Plantation of mulberry for rearing silkworm is considered a non-forest activity. The reason is same as described above.
- Mining is a non-forestry activity and prior approval of Central govt. is mandatory. The Supreme Court in a case *T.N. Godavarman Thirumulkpad Vs. Union of India (1997)* directed all on-going mining activity to be ceased immediately in any forest area of India if it had not got prior approval of Central government.
- Removal of stones, bajri, boulder etc. from river-beds located within the forest area fall under non-forest activity.
- Any proposal sent to Central govt. for non-forest activity must have a cost-benefit analysis and Environmental Impact Statement (EIS) of the proposed activity with reference to its ecological and socio-economic impacts.

Thus, the Forests (Conservation) Act has made ample provisions for conservation and protection of forests and prevent deforestation.

8.2.3 Water (Prevention and Control of Pollution) Act, 1974

It provides for maintaining and restoring the wholesomeness of water by preventing and controlling its pollution. ***Water pollution is defined as such contamination of water, or such alteration of the physical, chemical or biological properties of water, or such discharge as is likely to cause a nuisance or render the water harmful or injurious to public health and safety or harmful for any other use or to aquatic plants and other organisms or animal life.***

The definition of water pollution has thus encompassed the entire probable agents in water that may cause any harm or have a potential to harm any kind of life in any way.

The salient features and provisions of the Act are summed up as follows:

(*i*) It provides for maintenance and restoration of quality of all types of surface and ground water.

(*ii*) It provides for the establishment of Central and State Boards for pollution control.

(*iii*) It confers them with powers and functions to control pollution.

The Central and State Pollution Control Boards are widely represented and are given comprehensive powers to advise, coordinate and provide technical assistance for prevention and control of pollution of water.

(*iv*) The Act has provisions for funds, budgets, accounts and audit of the Central and State Pollution Control Boards.

(*v*) The Act makes provisions for various penalties for the defaulters and procedure for the same.

The main regulatory bodies are the Pollution Control Boards, which have been conferred the following duties and powers:

(A) Central Pollution Control Board (CPCB):

- It advises the Central govt. in matters related to prevention and control of water pollution.
- Coordinates the activities of State Pollution Control Boards and provides them technical assistance and guidance.
- Organizes training programs for prevention and control of pollution.
- Organizes comprehensive programs on pollution related issues through mass media.
- Collects, compiles and publishes technical and statistical data related to pollution.
- Prepares manuals for treatment and disposal of sewage and trade effluents.
- Lays down standards for water quality parameters.
- Plans nation-wide programs for prevention, control or abatement of pollution.
- Establishes and recognizes laboratories for analysis of water, sewage or trade effluent sample.

(B) The State Pollution Control Boards:

These boards also have similar functions to be executed at state level and are governed by the directions of CPCB.

- The Board advises the State govt. with respect to the location of any industry that might pollute a stream or a well.
- It lays down standards for effluents and is empowered to take samples from any stream, well or trade effluent or sewage passing through an industry.
- The State Board is empowered to take legal samples of trade effluent in accordance with the procedure laid down in the Act. The sample taken in the presence of the occupier or his agent is divided into two parts, sealed, signed by both parties and sent for analysis to some recognized lab. If the samples do not conform to the prescribed water quality standards (crossing maximum permissible limits), then 'consent' is refused to the unit.
- Every industry has to obtain consent from the Board (granted for a fixed duration) by applying on a prescribed proforma providing all technical details, along with a prescribed fee following which analysis of the effluent is carried out.
- The Board suggests efficient methods for utilization, treatment and disposal of trade effluents.

The Act has made detailed provisions regarding the power of the Boards to obtain information, take trade samples, restrict new outlets, restrict expansion, enter and inspect the units and sanction or refuse consent to the industry after effluent analysis.

While development is necessary, it is all the more important to prevent pollution, which can jeopardize the lives of the people. Installation and proper functioning of effluent treatment plants (ETP) in all polluting industries is a must for checking pollution of water and land. Despite certain weaknesses in the Act, the Water Act has ample provisions for preventing and controlling water pollution through legal measures.

8.2.4 The Air (Prevention and Control of Pollution) Act, 1981

Salient features of the act are as follows:

(*i*) The Act provides for prevention, control and abatement of air pollution.

(*ii*) In the Act, ***air pollution has been defined as the presence of any solid, liquid or gaseous substance (including noise) in the atmosphere in such concentration as may be or tend to be harmful to human beings or any other living creatures or plants or property or environment.***

(*iii*) Noise pollution has been inserted as pollution in the Act in 1987.

(*iv*) Pollution Control Boards at the Central or State level have the regulatory authority to implement the Air Act. Just parallel to the functions related to Water (Prevention and Control of Pollution) Act, the Boards perform similar functions related to improvement of air quality. The Boards have to check whether or not the industry strictly follows the norms or standards laid down by the Boards under section 17, regarding the discharge of emission of any air pollutant. Based upon analysis report consent is granted or refused to the industry.

(*v*) Just like the Water Act, the Air Act has provisions for defining the constitution, powers and function of Pollution Control Boards, funds, accounts, audit, penalties and procedures.

(*vi*) Section 20 of the Act has provision for ensuring emission standards from automobiles. Based upon it, the State govt. is empowered to issue instructions to the authority incharge of registration of motor vehicles (under Motor Vehicles Act, 1939) that is bound to comply with such instructions.

(*vii*) As per Section 19, in consultation with the State Pollution Control Board, the state government may declare an area within the state as **"air pollution control area"** and can prohibit the use of any fuel other than approved fuel in the area causing air pollution. No person shall, without prior consent of State Board operate or establish any industrial unit in the "air pollution control area".

The Water and Air Acts have also made special provisions for appeals. Under Section 28 of Water Act and Section 31 of Air Act, a provision for appeals has been made. An **Appellate Authority** consisting of a single person or three persons appointed by the Head of the State, the Governor, is constituted to hear such appeals as filed by some aggrieved party (industry) due to some order made by the State Board within 30 days of passing the orders.

The Appellate Authority after giving the appellant and the State Board an opportunity of being heard, disposes off the appeal as expeditiously as possible.

8.2.5 The Environment (Protection) Act, 1986

The Act came into force on Nov. 19, 1986, the birth anniversary of our late Prime Minister Indira Gandhi, who was a pioneer of environmental protection issues in our country. The Act extends to whole of India. Some terms related to environment have been described as follows in the Act:

(*i*) **Environment** includes water, air and land and the inter-relationships that exists among and between them and human beings, all other living organisms and property.

(*ii*) **Environmental pollution** means the presence of any solid, liquid or gaseous substance present in such concentration, as may be, or tend to be, injurious to environment.

(*iii*) **Hazardous substance** means any substance or preparation which by its physico-chemical properties or handling is liable to cause harm to human beings, other living organisms, property or environment.

The Act has given powers to the Central Government to take measures to protect and improve environment while the state governments coordinate the actions. The most important functions of Central govt. under this Act include setting up of:

(*a*) The standards of quality of air, water or soil for various areas and purposes.

(*b*) The maximum permissible limits of concentration of various environmental pollutants (including noise) for different areas.

(*c*) The procedures and safeguards for the handling of hazardous substances.

(*d*) The prohibition and restrictions on the handling of hazardous substances in different areas.

(*e*) The prohibition and restriction on the location of industries and to carry on process and operations in different areas.

(*f*) The procedures and safeguards for the prevention of accidents which may cause environmental pollution and providing for remedial measures for such accidents.

The power of entry and inspection, power to take sample etc. under this Act lies with the Central Government or any officer empowered by it.

For the purpose of protecting and improving the quality of the environment and preventing and abating pollution, standards have been specified under Schedule I-IV of Environment (Protection) Rules, 1986 for emission of gaseous pollutants and discharge of effluents/waste water from industries. These standards vary from industry to industry and also vary with the medium into which the effluent in discharged or the area of emission. For instance, the maximum permissible limits of B.O.D. (Biochemical Oxygen Demand) of the waste water is 30 ppm if it is discharged into inland waters, 350 ppm if discharged into a public sewer and 100 ppm, if discharged onto land or coastal region. Likewise, emission standards vary in residential, sensitive and industrial area. Naturally the standards for sensitive areas like hospitals are more stringent. It is the duty of the Pollution Control Board to check whether the industries are following the prescribed norms or not.

Under the **Environmental (Protection) Rules, 1986** the State Pollution Control Boards have to follow the guidelines provided under Schedule VI, some of which are as follows:

(*a*) They have to advise the industries for treating the waste water and gases with the best available technology to achieve the prescribed standards.

(*b*) The industries have to be encouraged for recycling and reusing the wastes.

(*c*) They have to encourage the industries for recovery of biogas, energy and reusable materials.

(*d*) While permitting the discharge of effluents and emissions into the environment, the State Boards have to take into account the assimilative capacity of the receiving water body.

(*e*) The Central and State Boards have to emphasize on the implementation of clean technologies by the industries in order to increase fuel efficiency and reduce the generation of environmental pollutants.

Under the Environment (Protection) Rules, 1986 an amendment was made in 1994 for Environmental Impact Assessment (EIA) of various development projects. There are 29 types of projects listed under Schedule I of the rule which require clearance from the Central Government before establishing.

Others require clearance from the State Pollution Control Board, when the proposed project or expansion activity is going to cause pollution load exceeding the existing levels. The project proponent

has to provide EIA report, risk analysis report, NOC from State Pollution Control Board, commitment regarding availability of water and electricity, summary of project report/feasibility report, filled in a questionnaire for environmental appraisal of the project and comprehensive rehabilitation plan, if more than 1000 people are likely to be displaced due to the project.

Under the Environment (Protection) Act, 1986 the Central Government also made the Hazardous Wastes (Management and Handling) Rules, 1989. Under these rules, it is the responsibility of the occupier to take all practical steps to ensure that such wastes are properly handled and disposed off without any adverse effects. There are 18 hazardous waste categories recognized under this rule and there are guidelines for their proper handling, storage, treatment, transport and disposal which should be strictly followed by the owner.

The Environment (Protection) Act, 1986 has also made provision for environmental audit as a means of checking whether or not a company is complying with the environmental laws and regulations. Thus, ample provisions have been made in our country through law for improving the quality of our environment.

8.3 INITIATIVES BY NON-GOVERNMENTAL ORGANIZATIONS

(A) Role:

Non-government organizations (NGOs) can play a very important role in protection of environment because they act at the grass-root level. Simple laws cannot be enforced that effectively unless there is proper awareness amongst the masses. The NGOs can play a dual role:

(*i*) They can act as watch-dogs and advice the government about some local environmental issues of prime and urgent concern

(*ii*) They can interact with the people at grass-root level, sharing their problems and concern. These NGO's can act as a viable link between the two.

They can act both as an "Action group" and a "pressure group" by leading public environmental movements.

(B) Drawbacks:

(*i*) Quite often NGO's are found to work with vested interests, without a genuine concern for the environment

(*ii*) They may get politically motivated. In such cases the public feels cheated and the enthusiasm to protect the environment is totally lost.

Nonetheless, all over the world the number of NGOs is increasing day by day and several initiatives have been taken by them for protection of environment in different ways.

(C) Initiatives:

Some major initiatives taken by NGO's are discussed here:

(*i*) **Dasholi Gram Swarajya Mandal** in Gopeshwar is known for the well known "Chipko Movement" for protecting the trees. Sh. Sunderlal Bahuguna's name is now synonymous with this movement, who led this movement in Uttarakhand against tree-felling.

(*ii*) **Kalpavriksh** is known for the "Narmada Bachao Andolan" headed by Medha Patekar, raising the major environmental issues associated with the Sardar Sarovar dam on the river, particularly the issue of displacement and rehabilitation of the natives/outsees.

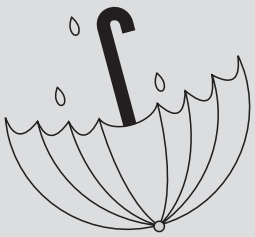
(*iii*) **Centre for Science and Environment (CSE)** have played a significant role in preparing 'Citizen's Report' and have taken up various prime issues in a scientific way. Pesticide levels in cola drinks exceeding the maximum permissible limits has sensitized the people all over the country.

(*iv*) **Bombay Natural History Society (BNHS)** is one of the oldest NGOs of India who have worked for the protection of wildlife.

(*v*) **Tarun Bharat Sangh**, Rajasthan, under the leadership of Sh. Rajendra Singh has done a remarkable job of harvesting rainwater by constructing check-dams, who was honoured with prestigious Magsaysay award for his work.

Water Conservation Efforts by CSE (case study)

Rainwater Harvesting



Late Sh. Anil Agarwal, Founder Director, and CSE tried to draw attention of general public towards conservation of water:

"The Real Green Revolution is about rainwater harvesting. Let us catch water where it falls. Let it transform human lives. Let it change social existence. If this happens, the world will be transformed. The world will merely be an agglomeration of ecological-rainwater harvesting-democracies."

In the recent years, there has been a revival of traditional water harvesting systems in various parts of India. Facing huge water crisis, rural communities have revived and created new water harvesting systems such as checkdams, *johads*, rooftop runoffs and other structures for harvesting every drop of water.

The Centre for Science and Environment (CSE) has launched a campaign to spread awareness about community-based rainwater harvesting techniques, and has identified 16 model projects in Delhi which are being monitored regularly. The systems are successfully running under different geographical and geological condition. In the Mira Model School, for example, it has been constructed on a sedimentary terrain while the Shri Ram School project is on a hilly terrain with different forms of rainwater harvesting *i.e.,* rooftop harvesting and surface water harvesting.

Paani Yatra

It is another novel way by which the CSE has prompted people to rediscover water by undertaking a trip to different villages where local communities have harvested rainwater and used it wisely. In the process, they have succeeded in achieving a dramatic revival of local ecology and economy. Paani yatra is a means to arouse awareness amongst individuals and organisations for water self-reliance, popularly called as ***Jal Swaraj***, which offers a unique opportunity to masses to attain water literacy.

Sunita Narain, Director, CSE, was awarded the "World Water Prize" in Stockholm in Aug. 2005 in recognition of the work done by CSE for water conservation.

Greenpeace is a world-wide NGO working for the protection of environment. This organization believes in peaceful mass movements for environmental protection. There is **Sea-shepherd**, another NGO, which is determined to stop killing of marine animals. This NGO even resorted to aggressive and violent means to achieve their goals.

8.4 ENVIRONMENTAL EDUCATION

8.4.1 Need for Environmental Education

Environmental education or environmental literacy is something that every person should be well versed with. The principles of ecology and fundamentals of environment can really help create a sense of earth-citizenship and a sense of duty to care for the earth and its resources and to manage them in a sustainable way so that our children and grand children too inherit a safe and clean planet to live on.

Following the Supreme Court directives (in M.C. Mehta Vs. Union of India, 1988) environmental education has been included in the curriculum right from the school stage to college/ university level. The prime objective of the same is to make everyone environment literate. The environment belongs to each one of us and our actions affect the environment. When the environment gets degraded it affects our health, well-being and our future. So we have a right to know the *a b c* of environment and also have a right to safe and clean environment.

8.4.2 Need for Value-based Environmental Education

Let us now see how environmental education be made value-oriented.

1. **Human values.** Preparation of textbooks and resource materials about environmental education can play an important role in building positive attitudes about environment. The basic human value **'man in nature'** rather than **'nature for man'** needs to be infused through the same.

2. **Social values.** Love, compassion, tolerance and justice which are the basic teachings of most of our religions need to be woven into environmental education. These are the values to be nurtured so that all forms of life and the biodiversity on this earth are protected.

3. **Cultural and religious values.** These are the values enshrined in Vedas like "*Dehi me dadami te" i.e.* "you give me and I give you" (Yajurveda) emphasize that man should not exploit nature without nurturing her. Our cultural customs and rituals in many ways teach us to perform such functions as would protect and nurture nature and respect every aspect of nature, treating them as sacred, be it rivers, earth, mountains or forests.

4. **Ethical values.** Environmental education should encompass the ethical values of earth-centric rather than human-centric world-view. The educational system should promote the earth-citizenship thinking. Instead of considering human being as supreme we have to think of the welfare of the earth.

5. **Global values.** The concept that the human civilization is a part of the planet as a whole and similarly nature and various natural phenomena over the earth are interconnected and inter-linked with special bonds of harmony. If we disturb this harmony anywhere there will be an ecological imbalance leading to catastrophic results.

6. **Spiritual values.** Principles of self-restraint, self-discipline, contentment, reduction of wants, freedom from greed and austerity are some of the finest elements intricately woven into the traditional and religious fabric of our country. All these values promote conservationism and transform our consumeristic approach.

The above-mentioned human values, socio-cultural, ethical, spiritual and global values incorporated into environmental education can go a long way in attaining the goals of sustainable development and environmental conservation. Value-based environmental education can bring in a total transformation of our mindset, our attitudes and our lifestyles.

8.4.3 Approaches to Impart Environmental Education

Environmental education needs to be imparted through formal and informal ways to all sections of the society. Everyone needs to understand it because 'environment belongs to all' and 'every individual matters' when it comes to conservation and protection of environment.'

Various stages and methods that can be useful for raising environmental awareness in different sections of the society are as follows:

(*i*) **Among students through formal education:** Environmental education must be imparted to the students right from the childhood stage. It is a welcome step that now all over the country we are introducing environmental studies as a subject at all stages including school and college level, following the directives of the Supreme Court.

(*ii*) **Among the masses through mass-media:** Media can play an important role to educate the masses on environmental issues through articles, environmental rallies, plantation campaigns, street plays, real eco-disaster stories and success stories of conservation efforts. TV serials like *Virasat, Race to Save the Planet, Heads and Tails, Terra-view, Captain planet* and the like have been effective in propagating the seeds of environmental awareness amongst the viewers of all age groups. (Plate VI, VII).

(*iii*) **Among the planners, decision-makers and leaders:** Since this elite section of the society plays the most important role in shaping the future of the society, it is very important to give them the necessary orientation and training through specially organized workshops and training programmes.

Publication of environment-related resource material in the form of pamphlets or booklets published by Ministry of Environment & Forests can also help in keeping this section abreast of the latest developments in the field.

8.5 WOMEN EDUCATION

8.5.1 Status of Women

In many developing countries, women do not enjoy the same rights and opportunities as men do. Women make roughly half of the world's population, but as per WHO estimates they carry out 67% of total work, but receive only 10% of world's income. These figures clearly show the wide gender bias. Representation of women in government, world's parliaments, higher education, high managerial

positions is gradually increasing, but still it is far behind that of men. It is an irony that women make up about 70% of the world's poor and about 67% of the illiterate people. Women, especially in developing countries, spend most of their time growing food, gathering fuelwood, bringing water and doing domestic work and child care.

8.5.2 Need for Women Education

(*i*) Educating the women will empower them to seek gender equality in the society.

(*ii*) Women will be able to earn that would raise their economic condition and their status in the society.

(*iii*) They will be aware about the advantages of small and planned family and this will be a big step towards achieving stabilized population goals.

(*iv*) It has been reported that the single most important factor affecting high total fertility rates (TFR) is the low status of women in many societies. Women education will help increase the age of marriage of women and they would tend to have fewer, healthier children who would live longer.

(*v*) Women on being educated would be able to rear their children in a better way, leading to their good health and provide them with better facilities.

(*vi*) Women are also the victim of capitalism and development. Due to some development activity like dam building or mining, they get dehabilitated. The menfolk get some compensation and migrate to towns in search of some job while women are left behind to look after the family with little resources. They are compelled to take up some marginalized work, which is highly unorganized and often socially humiliating. Women education can greatly help restore their settlement and dignity.

(*vii*) Education of women would mean narrowing down of social disparities and inequities. This would automatically lead to sustainable development.

I. QUESTIONS

1. Discuss the salient features of (*a*) Wildlife (Protection) Act, 1972 (*b*) Forest (Conservation Act), 1980.
2. How do you define pollution as per Water (Prevention and Control of Pollution) Act, 1974 ? What are the salient features of the Act ?
3. Who has the authority to declare an area as "air pollution control area" in a state under the Air (Prevention and Control of Pollution) Act, 1981 ? When was noise inserted in this act ?
4. Why do we refer to Environmental Protection Act, 1986 as an Umbrella Act ? Discuss the Major Environmental Protection Rules, 1986.
5. What are the major limitations to successful implementation of our environmental legislation ?
6. What are the different methods to propagate environmental awareness in the society ?
7. Discuss the role of NGO's in environmental protection giving examples.
8. How can environmental education be made value oriented?
9. What are the methods of imparting environmental education?
10. Discuss the importance of women education.

II. OBJECTIVE TYPE QUESTIONS

(A) FILL IN THE BLANKS

1. The first country in the world to make provisions for environmental protection in its constitution is ..... .

2. ..... Act provides for setting up of national parks and wildlife sanctuaries.

3. Noise has been included as pollution in the air (Prevention and control of polution) Act, 1981 in the year ..... .

4. Any appeals filed by the aggrieved industrial unit against the State Pollution Control Board are heard and decided by ..... authority, under the Water and Air Acts.

5. Environmental Protection Act came into force on ..... 1986 the birth anniversary of Smt. Indira Gandhi.

6. There are ..... types of projects which require clearance from central government before establishment.

7. Narmada Bachao Anadolan has been launched by the NGO named .....

8. Environmental education has been made compulsory by the Supreme Court based upon the PIL filed by ..... .

(B) CHOOSE THE CORRECT ANSWER

1. Rajendra Singh of ''Tarun Bharat Sangh'' was awarded Magsaysay Award for his work on

(*a*) Water conservation (*b*) Social forestry

(*c*) Clean technology (*d*) Popularisation of solar energy.

2. Which article in constitution recognizes environmental protection as one of the fundamental duties of every citizen of India ?

(*a*) Article 42 (*b*) Article 48A

(*c*) Article 51A(g) (*d*) Article 52.

3. As per the Forest Act, cultivation of which of the following is a non-forest activity

(*a*) Tea (*b*) Rubber

(*c*) Mulberry (*d*) All of these.

4. Which of the following NGO's is associated with 'Chipko Movement' ?

(*a*) Kalpavriksh (*b*) Srishti

(*c*) Dasholi Gram Swarajya Mandal

(*d*) Green Peace.

5. The sensitizing issue of pesticide contamination of cola drinks was brought into limelight by the NGO

(*a*) Centre for Science and Environment

(*b*) Bombay Natural History Society

(*c*) Kerala Sastra Sahitya Parishad

(*d*) Kalpavriksh.

(C) WRITE TRUE OR FALSE

1. The Wildlife (Protection) Act, 1972 is adopted all over India including Jammu & Kashmir. (True/False)

2. For any non-forest activity in the forest prior approval of State Govt. is necessary, as per the 1992 amendment in Forest Act. (True/False)

3. The definition of water pollution as per Water (Prevention and Control of Pollution) Act, 1974 includes not only the agents causing harm to any form of life but also those which have a likelihood of doing so. (True/False)

4. Central and State Pollution Control Boards were established in 1996 under the Environmental (Protection) Act. (True/False)

5. One of the major drawbacks of the Forest Conservation Act, 1980 is very poor community participation in it. (True/False)

6. Paani Yatra is a way by which the people visit different villages to know and revive the local rain water harvesting technologies. (True/False)

7. For environmental protection we should emphasize on human-centric world view in environmental education. (True/False)

8. As per W.H.O. estimates the women carryout 2/3 of the total work and receive 50% of the world's income. (True/False)

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Glossary

abiotic	: Non living.
age-structure	: Percentage of men and women in the young, adult and old stage in a population.
acid rain	: Toxic gases like SOx and NOx dissolve in rain water to form sulphuric acid and nitric acid and come down as acid rain.
aerobic	: An organism that needs oxygen to carry on.
anaerobic	: An organism that lives in the absence of oxygen.
air pollution	: Toxic chemicals, excess heat or noise present in the atmosphere in concentrations that are or may be harmful to humans, other animals or plants.
altitude	: Height above sea-level.
alpha particle	: Positively charged matter that consists of two protons and two neutrons.
ambient air	: The air surrounding us.
animal husbandry	: Raising of livestock like sheep, pigs, chicken, cows, goats etc.
annual	: Occurring in a year.
aquifer	: A highly permeable layer of sediment or rock containing water.
arid	: Dry
atmosphere	: The mass of air surrounding the earth.
autotroph	: Organisms that synthesize their own food *e.g.* green plants.
aerosol	: Minute particles and droplets suspended in the air.
allergens	: Substances causing allergy.
anthropogenic	: Human generated; caused by humans.
bioaccumulation	: Accumulation of non-biodegradable substances in the body.
biodegradable	: Substances that can be broken down by microbes.
biodiversity	: Total variability among species of plants, animals and microorganisms.
biogeochemical cycles	: Cycling of nutrients among living organisms, air, water and soil.
biohydrogen	: Hydrogen produced by microorganisms like algae and bacteria during photosynthesis or fermentation.

biomagnification	: Increase in concentration of some stable compounds at successive trophic levels in a food chain.
biomedical waste	: Anatomical and pathological wastes.
B.O. D.	: Biological oxygen demand. It is the amount of dissolved oxygen required by microorganisms to break down organic matter present in water.
biomass	: Organic matter produced by living organisms.
biosphere	: Zone of earth where life is found. It includes air, water and soil.
biotic	: Living
cancer	: A disease producing tumor in which cells multiply uncontrollably and invade surrounding tissue.
carcinogen	: Any agent promoting cancer *e.g.* chemicals, ionizing radiations etc.
carnivore	: Organism that feeds on other animals.
carrying capacity	: Maximum population size that a given system can support over a given period of time.
cell	: The smallest unit of living organisms.
chlorofluorocarbons (CFCs)	: Chemical compounds with a carbon s keleton and one or more attached chlorine and fluorine atoms; used as refrigerant, solvent, fire retardant and blowing agent.
chemosynthesis	: Conversion of inorganic substances into organic compounds (by bacteria) in the absence of sunlight.
chlorophyll	: Green coloured pigment found in green plants.
climate	: Long-term pattern of weather in a particular area.
closed ecosystem	: Ecosystem having little exchange of nutrients and energy with outside environment.
coliform bacteria	: Bacteria living in the colon region of human intestine; used as an index of faecal contamination of water.
consumerism	: Consumption or use of resources.
community	: Populations of various species living and interacting in a given area.
compost	: A nutrient rich soil amendment produced by biological degradation of organic material under aerobic conditions
condensation nuclei	: Tiny particles on which droplets of water vapour can collect.
consumer	: Organism who cannot synthesize its own food and get its nutrition by feeding on others.
consumption overpopulation	: When resource use is at a very high rate resulting in large-scale waste generation and environmental degradation; found in developed nations with less population.

contraceptives : Physical or chemical methods used for family planning.

cyanobacteria : Blue green algae.

confined aquifer : Aquifer between two relatively impermeable layers of earth.

cybernetic system : Self-regulation or control of a system

DDT : Dichlorodiphenyltrichloroethane, a pesticide.

decomposers : Fungi and bacteria that break complex organic matter into simpler molecules and ultimately into inorganic substances.

demography : Study of human populations.

demographic transition : A pattern of falling death rates and birth rates in response to improved living conditions due to industrialization.

desert : A biome where evaporation exceeds precipitation.

desertification : Degradation of once fertile land into a desert like land.

detritivore : Organism that consumes organic litter, debris and dung.

dioxins : A family of 75 different chlorinated hydrocarbon compounds produced as by-products at high temperature in chemical reactions, usually carcinogenic.

DNA : Deoxyribonucleic acid, genetic material.

doubling time : Time taken by something (population) to double itself.

drought : Condition in which an area does not get enough water due to below normal rainfall.

detritus : Dead organic matter.

deuterium : Isotope of hydrogen, the nucleus has one proton and one neutron, mass number: 2.

earthquake : Shaking of ground due to fracturing and displacement of rocks on the earth's crust.

eco-centric : A life view advocating moral values and rights both for the human beings and the earth.

ecology : Study of interactions of living organisms with their biotic and abiotic environment.

ecological succession : The process by which one community is naturally replaced by another one over a period of time.

ecological services : Processes or materials provided by ecosystems like pure air, water, nutrients.

ecomark : Scheme of labelling eco-friendly consumer products.

ecosystem : A biological community and its physical environment exchanging matter and energy.

ecotourism : Synthesis of tourism with appreciation of nature and its wildlife.

endemism : Restriction of a species to a single region.

energy : Capacity to do work.

environment	: The conditions surrounding organisms including all biotic, abiotic components and their interactions.
ethics	: Moral values and principles to guide us.
environmental impact assessment (EIA)	: A systematic analysis of the effects of a major development project.
electromagnetic radiations	: Kinetic energy moving as electromagnetic waves *e.g.* TV waves, radio-waves, visible light etc.
environmental studies	: A systematic study of our environment as well as our role in it.
estuary	: Partially enclosed coastal area at the mouth of a river where fresh and salt water meet.
eutrophication	: Over-nourishment of water bodies due to excessive nitrates and phosphates received through run-off.
e-waste	: Electronic waste arising for discarded electronic goods or parts (battery, CD, floppy, wire, cable plastic cases etc.).
exponential growth	: Growth at a constant rate of increase per unit of time.
extinction	: Loss of a species from the earth; a species is said to be extinct if it is not seen in the wild for 50 years.
family planning	: Planning the timing, spacing and number of offsprings.
famine	: Acute food shortage.
fauna	: All the animals present in a given region.
feedback mechanism	: A mechanism to sense, evaluate and react to environmental changes as a result of information feedback into the system.
fertilizer	: Substance that adds inorganic or organic nutrients to the soil to improve yield.
flora	: All plants present in a given region.
food chain	: A feeding series in an ecosystem.
food security	: Ability of human beings to obtain adequate food on regular basis.
food web	: A complex, interlocking series of food chains.
fossil fuels	: Fuels produced due to fossilization of plants/animals like petroleum, coal, natural gas.
fungi	: A group of plants which lack the green pigment chlorophyll, *e.g.* mushrooms, molds etc.
fungicides	: Chemicals that kill fungi.
gamma rays	: Very short wavelength ionizing rays with high energy.

gasohol : A fuel that is a mixture of gasoline and alcohol.

gene : A unit of heredity, it is either DNA or RNA.

glacier : A flowing body of ice.

GNP : Gross National Product, an index of a country's economic develoment.

greenhouse effect : Trapping of heat by earth's atmosphere due to greenhouse gases like carbon-dioxide, methane, water vapour etc.

groundwater : Water held in aquifers below the earth's surface.

habitat : Place where an organism lives.

half life : Time required by a substance to decay by half.

heterotroph : Organism that can't synthesize its own food and derives its nourishment by feeding on others.

homeostasis : An inherent property of living organisms or ecosystems to resist change and remain stable.

humus : A dark amorphous substance that is partially degraded and serves as a major source of nutrients to plants.

hydrocarbon : Organic compounds of hydrogen and carbon.

HIV : Human immunodeficiency virus—a virus causing the dreaded disease AIDS.

incineration : Burning of materials at high temperature generally exceeding 900°C.

infiltration : Percolation of water into the soil.

insolation : Incoming solar radiations.

industrial smog : Air pollution due to a mixture of sulphur dioxide suspended solid particles.

infant mortality rate : Number of infants per 1000 born that die before their first birthday.

invertebrates : Animals that have no backbone.

ion : Atoms with a positive or negative charge.

isotopes : Two or more forms of an element that have same number of protons but different mass number due to different number of neutrons.

latitude : Distance from the equator.

leaching : Process in which various chemicals in upper layers of soil are dissolved and carried to lower layers.

lethal dose : The amount of a substance per unit of body weight that kills all the test animals.

life expectancy : Average number of years a new born baby is expected to live.

landslides : Mass movement of rock or soil down hill.

lithosphere : Outer shell of the earth composed of the crust and the rigid outermost part of the mantle.

magma : Molten rock below the earth surface.

malnutrition : Diet with deficiency of proteins.

mass number : Sum of number of neutrons and protons in the nucleus.

matter : Anything that has mass *e.g.* nutrients.

monoculture : Cultivation of a single crop or tree.

mutagen : Chemical or ionizing radiation that cause mutations.

mutation : A sudden heritable change.

marsh : A wetland without trees.

natural gas : Underground deposits of gases containing mainly methane and small amounts of propane and butane.

natural hazards : Hazards that destroy or damage wild life habitats, damages property and human settlements.

necrosis : Appearance of dead tissues.

net primary productivity : Rate at which plants produce biomass from sunlight.

neutron : Elementary particle in the nuclei of all atoms having no electric charge, relative mass = 1 (except hydrogen).

niche : The functional role and position of a species in an ecosystem *i.e.* what resources it uses, how it interacts with other species etc.

nitrogen fixation : Conversion of atmospheric nitrogen gas into ammonia by nitrogen fixing bacteria/cyanobacteria or by electrification.

nuclear fission : Nuclei of certain isotopes with large mass number are split apart into lighter nuclei when struck by a neutron releasing large amount of energy.

nuclear fusion : Two nuclei of isotopes of lighter elements fuse to form a heavier nucleus releasing a large amount of energy.

ore : A metal yielding material.

organic farming : Farming involving organic fertilizers and natural pest control, no use of inorganic fertilizers and pesticides.

oustees : Native people rooted out of their land/home due to developmental activity.

omnivores : Organisms that eat both plants and animals.

PAN : Peroxyacyl nitrate—a group of chemicals causing photochemical smog.

particulate matter : Solid particles or liquid droplets suspended in air.

parts per million (ppm) : Number of parts of a chemical found in one millionparts of a liquid/gas *e.g.* mg/L.

pathogen : Organism that causes disease.

peat : Semi-decayed organic matter.

perennial species : Plants that grow for more than two years.

pH : Numeric value that indicates the relative acidity or alkalinity; varies from 0-14 with neutral point at 7; less than 7 is acidic and more than 7 is alkaline.

photochemical smog : Mixture of air pollutants (generally coming along with vehicular exhaust) consisting of hydrocarbons and oxides of nitrogen and formed in the presence of sunlight.

photosynthesis : Synthesis of food by green plants in the presence of sunlight using carbon dioxide and water.

photovoltaic cell (PV cell) : Solar cell that converts solar energy into electricity.

phytoplanktons : Small plants like algae, bacteria found floating on the surface of water.

point source : A single identifiable source that discharges pollutants into the environment.

polychlorinated biphenyls (PCBs) : Group of 209 different toxic, oily, synthetic chlorinated hydrocarbons, biomagnified usually in food chain.

population : Group of individual organism of a species living within a particular area.

population explosion : Exponential growth of population to a size that exceeds the carrying capacity.

predator : Organism that feeds directly on other organism to survive.

primary pollutants : Pollutants released directly into the air.

public health : Protection and promotion of healthy human environment.

putrefaction : Break down of organic matter by anaerobic bacteria.

radioactive substance : The substance (isotope) that spontaneously emits one or more types of radiations like alpha particles, beta particles or gamma rays.

runoff : The excess of precipitation that does not evaporate or infiltrate.

rangelands : Grasslands.

remediation : Cleaning up chemical contaminants from polluted area.

rehabilitation : Re-establishing the oustees OR restructuring the ecological system that has been degraded.

residence time : The length of time for which a chemical or molecule stays in the environment.

salinity : Amount of soluble salts in water or soil.

sanitary landfill : Waste disposal site on land in which waste is spread in thin layers, compacted and covered with fresh layer of clay.

secondary pollutant : Pollutants formed by the reaction of two or more primary pollutants in the air.

sewage	: Wastewater originating from community usage.
sewerage	: Underground conduit used for carrying sewage.
sludge	: Settled solids removed from wastewaters.
smelting	: Process of separating the desired metal from an ore.
species	: All the organisms genetically similar, breeding freely but reproductively isolated from other species.
stress	: Such factors that cause a strain on an organism.
sustainable development	: Increase in standard of life that can be maintained over a long-term without degrading the environment or compromising the ability of future generations to meet their own needs.
synergism	: When the effect of two factors together is more than the sum of exposure to each factor individually.
tailings	: Mining wastes.
teratogens	: Chemicals or other agents that cause abnormalities during embryonic growth and development.
thermodynamics	: A branch that deals with transfer and conversions of energy.
total fertility rate (TFR)	: Average number of children born to a woman in her life time.
toxins	: Poisonous chemicals harmful even in small concentrations.
transpiration	: Loss of water from plant surfaces.
troposphere	: The layer of air nearest to earth's surface; both temperature and pressure usually decrease in this layer with increasing altitude.
stratosphere	: Second layer in the atmosphere above troposphere.
urbanization	: Increasing concentration of population in cities.
unconfined aquifer	: Groundwater above a layer of earth material with low permeability.
vertebrates	: Animals with backbones.
volcano	: Emission of magma from a fissure/vent in earth's surface releasing liquid lava and gases.
water logging	: Saturation of soil with irrigation water or excessive precipitation so that water table rises close to surface.
watershed	: The land area from which water drains under gravity to a common drainage channel.

weather pollution	:	Description of physical conditions of the atmosphere. Environmental condition in which certain substances (including the normal constituents in excess) are present in concentrations that can cause undesirable effects on man and his environment.
wetlands	:	Ecosystems with standing water and having rooted vegetation.
wildlife	:	Undomesticated life forms.
X-ray	:	Very short wavelength rays, useful in medical diagnosis. Can cause mutations.
zero population growth (ZPG)	:	When births and immigration in a population just equals deaths and emigration.
zooplankton	:	Small floating animals on surface of water feeding on phytoplanktons.

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